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NACA

RESEARCH MEMORANDUM

SURFACE-PRESSURE DISTRIBUTIONS ON A SYSTEMATIC GROUP OF NACA 1-SERIES COWLINGS WITH AND WITHOUT SPINNERS

By

Robert W. Boswinkle, Jr., and Arvid L. Keith, Jr.

Langley Aeronautical Laboratory
Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

November 30, 1948

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RESEARCH MEMORANDUM

SURFACE-PRESSURE DISTRIBUTIONS ON A SYSTEMATIC GROUP OF NACA 1-SERIES COWLINGS WITH AND WITHOUT SPINNERS

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SUMMARY

A method for calculating the flow fields of axially symmetric bodies from their pressure distributions is reported in NACA RM No. L8I17. In order to facilitate application of this method to the important case of the cowling-spinner combination, for use in the design of propellers, the present paper presents static-pressure distributions on the tops of 79 high-critical-speed NACA 1-series cowling-spinner combinations over wide ranges of inlet-velocity ratio at angles of attack of 0°, 2°, 4°, and 6°. Static-pressure distributions around the nose sections of several cowlings are given in greater detail to aid in estimating the pressures near the stagnation points and to show the effect of changes in the internal lip shape. The effects of the operation of a typical propeller on the surface pressures on the cowling are shown for one configuration. The pressure distributions over the nine NACA 1-series nose inlets used as the basic components of these combinations are also presented to supplement the existing open-nose-cowling data of NACA ACR No. L5F30a which are applicable to the case of the rotating cowling.

INTRODUCTION

A detailed knowledge of the flow field of the fuselage or nacelle is required in the process of propeller design in order to realize maximum propeller efficiency and, in the case of the cowling-spinner combination, to obtain a high pressure recovery in the cowling inlet. A method for calculating such a flow field from the surface pressures on the body is described in reference 1. Systematic pressure-distribution data for high-critical-speed NACA 1-series nose inlets (which may be used directly as rotating cowlings wherein the forward portions rotate with the propellers) are available in reference 2. The purpose of the present paper is to present similar pressure-distribution data for the 79 high-critical-speed NACA 1-series cowling-spinner combinations investigated in reference 3. Pressure distributions over the nine NACA 1-series nose inlets used as the

basic components of these combinations are included to supplement the data of reference 2.

SYMBOLS AND NOMENCLATURE

d	cowling inlet diameter (See table I)
D	maximum cowling diameter
D_p	propeller diameter
D_s	maximum spinner diameter (located at cowling inlet)
M	Mach number in undisturbed stream
p	local static pressure
p_o	static pressure in undisturbed stream
P	static-pressure coefficient $\left(\frac{p - p_o}{q_o}\right)$
q_o	dynamic pressure in undisturbed stream
T_c	propeller thrust-disk-loading coefficient $\left(\frac{\text{Thrust}}{2q_o D_p^2}\right)$
x	distance from inlet parallel to cowling axis
x_s	distance from nose of spinner parallel to cowling axis
X	cowling length, measured from inlet to maximum diameter station
X_s	spinner length measured from spinner nose to maximum diameter station of spinner (which is located at the inlet)
V_i/V_o	inlet-velocity ratio; ratio of average axial velocity of air in inlet to velocity in undisturbed stream
α	angle of attack of model, degrees

The NACA 1-series nose-inlet ordinates and the method of their application to the design of the cowlings and spinners used in the investigation are given in table I. An NACA 1-series cowling-spinner combination having $\frac{d}{D} = 0.70$, $\frac{X}{D} = 1.00$, $\frac{D_s}{D} = 0.40$, and $\frac{X_s}{D} = 0.80$ is identified as the NACA 1-70-100 cowling with the NACA 1-40-080 spinner. Thus, in each designation the first term indicates that the NACA 1-series ordinates are used; the second term gives the cowling-inlet diameter or the maximum spinner diameter as a percentage of the maximum cowling diameter; and the third term gives the cowling or spinner length as a percentage of the maximum cowling diameter.

MODEL AND TESTS

The model and instrumentation used in the tests are described in reference 3. The tests were made in the Langley propeller-research tunnel. The nine NACA 1-series cowlings and 11 NACA 1-series spinners investigated are shown in table II. Pressure surveys of each configuration were made with the propeller removed for from 11 to 18 values of inlet-velocity ratio at angles of attack of 0°, 2°, 4°, and 6°. With a 5.7-foot-diameter three-blade propeller of conventional design (reference 3) installed, pressure surveys of one configuration were conducted at angles of attack of 0° and 6° at propeller thrust-disk-loading coefficients of 0.02, 0.06, and 0.12. A tunnel speed of 100 miles per hour, which corresponds to a Mach number of 0.13 and a Reynolds number of about 2×10^6 based on the maximum cowling diameter (27.25 in.), was used for the majority of the tests. For the configurations having very large inlet areas and for all configurations at inlet-velocity ratios above 1.3, the tunnel speed was reduced to 70 miles per hour to obtain the required inlet-velocity ratios with the limited capacity of the internal fan.

DATA

The static-pressure distributions on the tops of the cowling configurations are presented in figures 1 to 88; an index of these figures is given in table III. At zero angle of attack these measured static-pressure distributions are directly applicable to any plane through the axis of symmetry. Check tests showed that these pressure distributions also are almost identical to the pressure distributions on the sides of the cowlings at angles of attack up to about 10°. Further, it may be shown from the experimental data of reference 4 that the pressure distributions on the bottoms of the cowlings at a positive angle of attack may be estimated by extrapolating the pressure-distribution data for the tops at positive angles of attack. Thus, the pressure distribution for the

entire surface of any NACA 1-series cowling-spinner combination within the range of proportions investigated may be obtained at angles of attack from 0° to 6° with acceptable accuracy from the figures of the present report.

Static-pressure distributions around the nose sections of representative NACA 1-series cowlings are given in greater detail in figure 89 to aid in estimating the static pressures near the stagnation point. The effect of a modification to the inner lip shape on the static-pressure distribution around the cowling nose is shown in figure 90. For the purposes of reference 1, it has been found satisfactory to estimate the pressure distributions on the walls of the interior ducting from one-dimensional-area considerations.

The effect of propeller operation on the static- and total-pressure distributions on the top of a typical cowling is shown in figures 91 and 92.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

REFERENCES

1. Boswinkle, Robert W., Jr.: A Method for Calculating Flow Fields of Cowlings with Known Surface-Pressure Distributions. NACA RM No. L8I17, 1948.

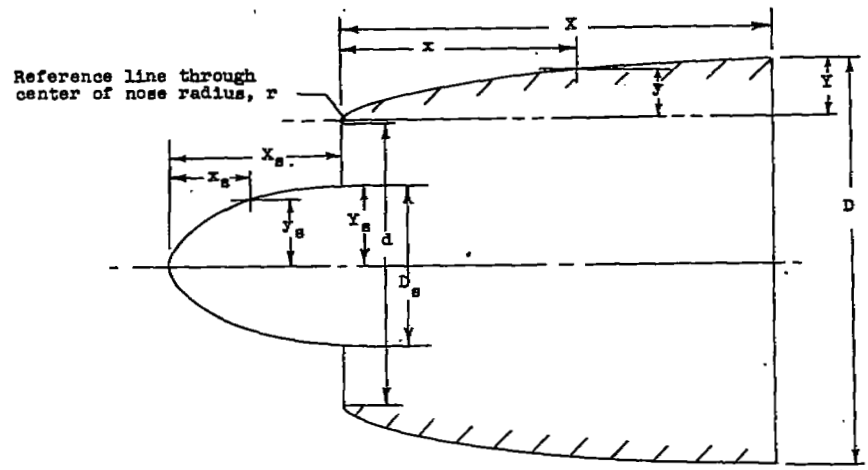
2. Baals, Donald D., Smith, Norman F., and Wright, John B.: The Development and Application of High-Critical-Speed Nose Inlets. NACA ACR No. L5F30a, 1945.

3. Nichols, Mark R., and Keith, Arvid L., Jr.: Investigation of a Systematic Group of NACA 1-Series Cowlings with and without Spinners. NACA RM No. L8A15, 1948.

4. Boswinkle, Robert W., Jr.: Air-Flow Surveys in the Vicinity of Representative NACA 1-Series Cowlings. NACA RM No. L8A15a, 1948.

TABLE I

NACA 1-SERIES ORDINATES AS APPLIED TO COWLING AND SPINNER



$$x = \left(\frac{X}{D}\right) D \qquad X_s = \left(\frac{X_s}{D}\right) D$$

$$Y = \frac{D - d}{2} - r \qquad Y_s = \frac{D_s}{2} = \frac{\left(\frac{D_s}{D}\right) D}{2}$$

For $r = 0.025Y$:

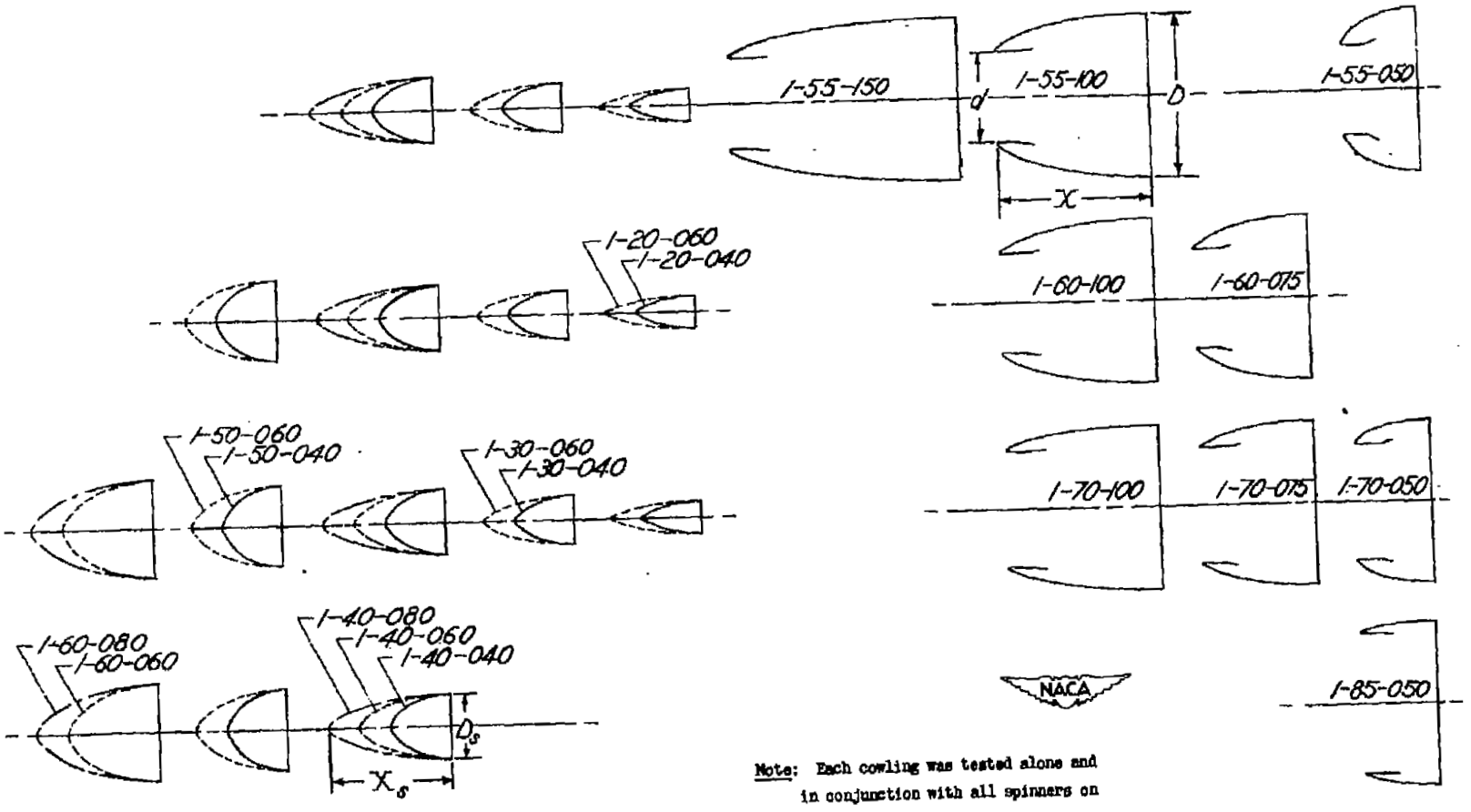
$$Y = \frac{D - d}{2.05} = \frac{D\left(1 - \frac{d}{D}\right)}{2.05}$$

[Ordinates in percent; taken from reference 3]

x/X or x_s/X_s	y/Y or y_s/Y_s	x/X or x_s/X_s	y/Y or y_s/Y_s	x/X or x_s/X_s	y/Y or y_s/Y_s	x/X or x_s/X_s	y/Y or y_s/Y_s
0	0	13.0	41.94	34.0	69.08	60.0	89.11
.2	4.80	14.0	43.66	35.0	70.08	62.0	90.20
.4	6.63	15.0	45.30	36.0	71.05	64.0	91.23
.6	8.12	16.0	46.88	37.0	72.00	66.0	92.20
.8	9.33	17.0	48.40	38.0	72.94	68.0	93.11
1.0	10.38	18.0	49.88	39.0	73.85	70.0	93.95
1.5	12.72	19.0	51.31	40.0	74.75	72.0	94.75
2.0	14.72	20.0	52.70	41.0	75.63	74.0	95.48
2.5	16.57	21.0	54.05	42.0	76.48	76.0	96.16
3.0	18.31	22.0	55.37	43.0	77.32	78.0	96.79
3.5	19.94	23.0	56.66	44.0	78.15	80.0	97.35
4.0	21.48	24.0	57.92	45.0	78.95	82.0	97.87
4.5	22.96	25.0	59.15	46.0	79.74	84.0	98.33
5.0	24.36	26.0	60.35	47.0	80.50	86.0	98.74
6.0	27.01	27.0	61.52	48.0	81.25	88.0	99.09
7.0	29.47	28.0	62.67	49.0	81.99	90.0	99.40
8.0	31.81	29.0	63.79	50.0	82.69	92.0	99.65
9.0	34.03	30.0	64.89	52.0	84.10	94.0	99.85
10.0	36.13	31.0	65.97	54.0	85.45	96.0	99.93
11.0	38.15	32.0	67.03	56.0	86.73	98.0	99.98
12.0	40.09	33.0	68.07	58.0	87.95	100.0	100.00

Cowling nose radius: 0.025Y

Table II.- NACA 1-Series Cowlings and Spinners Tested.



Note: Each cowling was tested alone and in conjunction with all spinners on same horizontal lines.

TABLE III.- INDEX TO SURFACE-PRESSURE DISTRIBUTIONS FOR NACA 1-SERIES COWLING-SPINNER COMBINATIONS AND OPEN-NOSE INLETS

Figure	Cowling	Spinner	Figure	Cowling	Spinner
1	1-55-050	No spinner	45	1-70-050	No spinner
2	---do---	1-20-040	46	---do---	1-20-040
3	---do---	1-30-040	47	---do---	1-30-040
4	---do---	1-40-040	48	---do---	1-40-040
5	---do---	1-20-060	49	---do---	1-50-040
6	---do---	1-30-060	50	---do---	1-20-060
7	---do---	1-40-060	51	---do---	1-30-060
8	---do---	1-40-080	52	---do---	1-40-060
9	1-55-100	No spinner	53	---do---	1-50-060
10	---do---	1-20-040	54	---do---	1-60-060
11	---do---	1-30-040	55	---do---	1-40-080
12	---do---	1-40-040	56	---do---	1-60-080
13	---do---	1-20-060	57	1-70-075	No spinner
14	---do---	1-30-060	58	---do---	1-20-040
15	---do---	1-40-060	59	---do---	1-30-040
16	---do---	1-40-080	60	---do---	1-40-040
17	1-55-150	No spinner	61	---do---	1-50-040
18	---do---	1-20-040	62	---do---	1-20-060
19	---do---	1-30-040	63	---do---	1-30-060
20	---do---	1-40-040	64	---do---	1-40-060
21	---do---	1-20-060	65	---do---	1-50-060
22	---do---	1-30-060	66	---do---	1-60-060
23	---do---	1-40-060	67	---do---	1-40-080
24	---do---	1-40-080	68	---do---	1-60-080
25	1-60-075	No spinner	69	1-70-100	No spinner
26	---do---	1-20-040	70	---do---	1-20-040
27	---do---	1-30-040	71	---do---	1-30-040
28	---do---	1-40-040	72	---do---	1-40-040
29	---do---	1-50-040	73	---do---	1-50-040
30	---do---	1-20-060	74	---do---	1-20-060
31	---do---	1-30-060	75	---do---	1-30-060
32	---do---	1-40-060	76	---do---	1-40-060
33	---do---	1-50-060	77	---do---	1-50-060
34	---do---	1-40-080	78	---do---	1-60-060
35	1-60-100	No spinner	79	---do---	1-40-080
36	---do---	1-20-040	80	---do---	1-60-080
37	---do---	1-30-040	81	1-85-050	No spinner
38	---do---	1-40-040	82	---do---	1-40-040
39	---do---	1-50-040	83	---do---	1-50-040
40	---do---	1-20-060	84	---do---	1-40-060
41	---do---	1-30-060	85	---do---	1-50-060
42	---do---	1-40-060	86	---do---	1-60-060
43	---do---	1-50-060	87	---do---	1-40-080
44	---do---	1-40-080	88	---do---	1-60-080

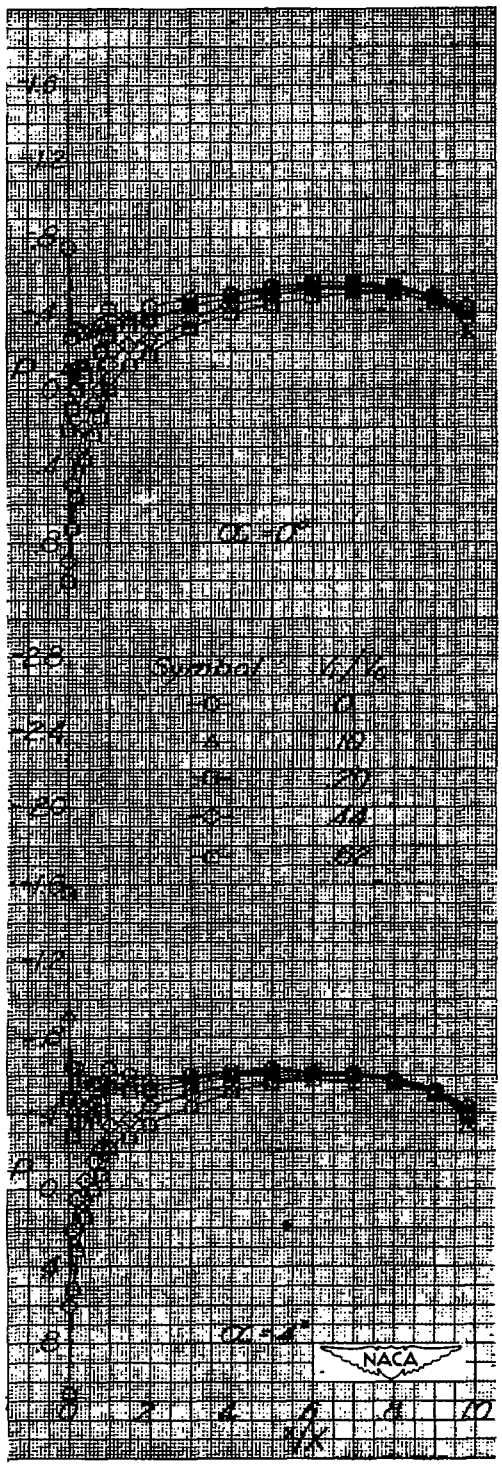


Figure 1.- Static-pressure distributions on top of NACA 1-55-050 open-nose cowling.

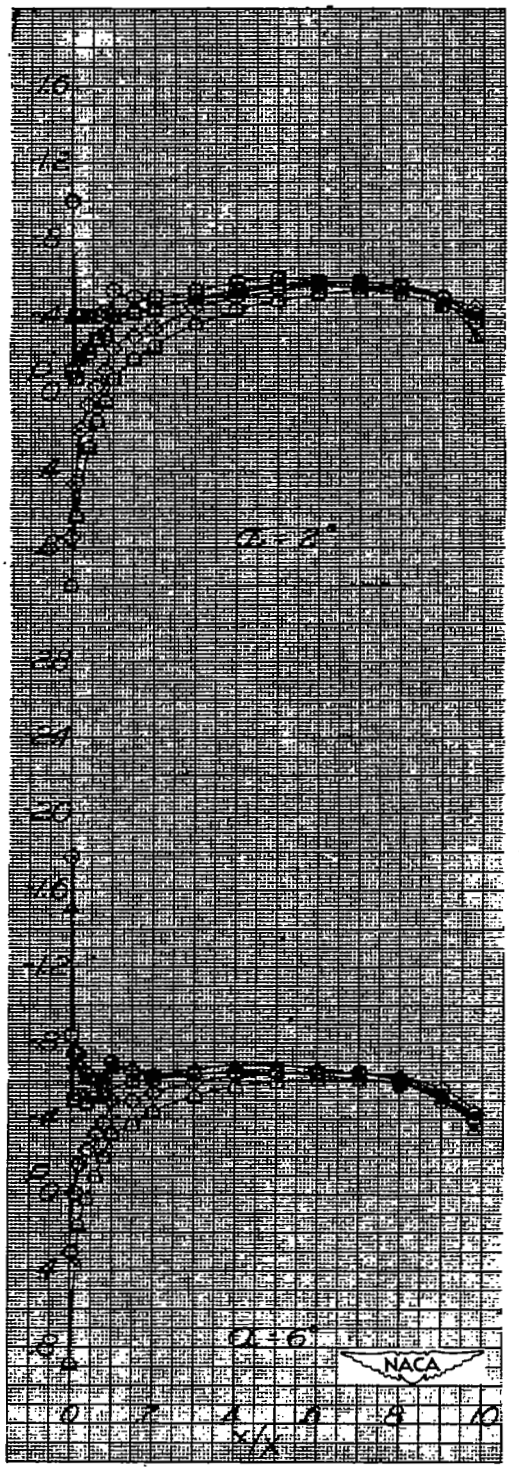


Figure 1.- Concluded.

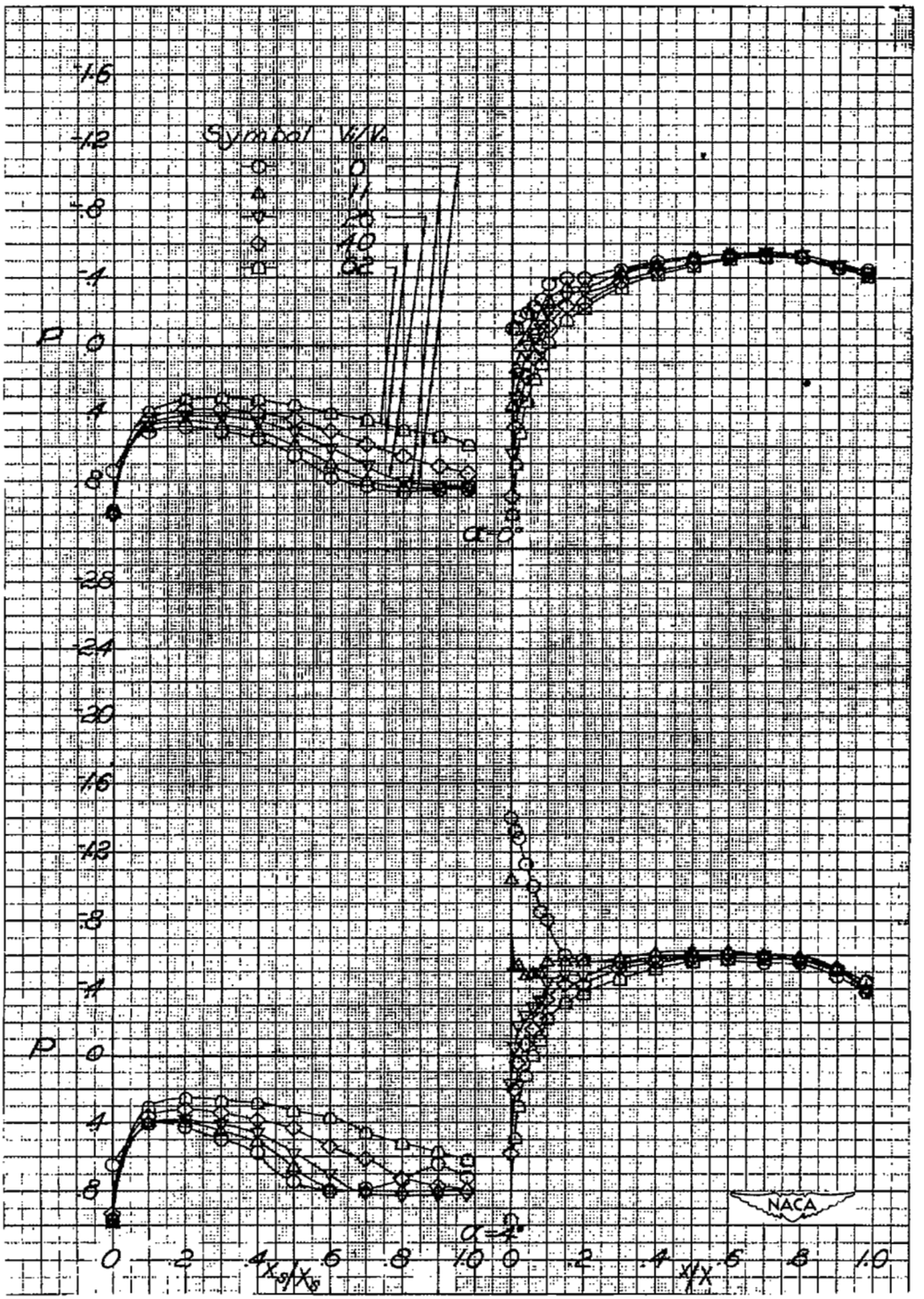


Figure 2.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-20-040 spinner.

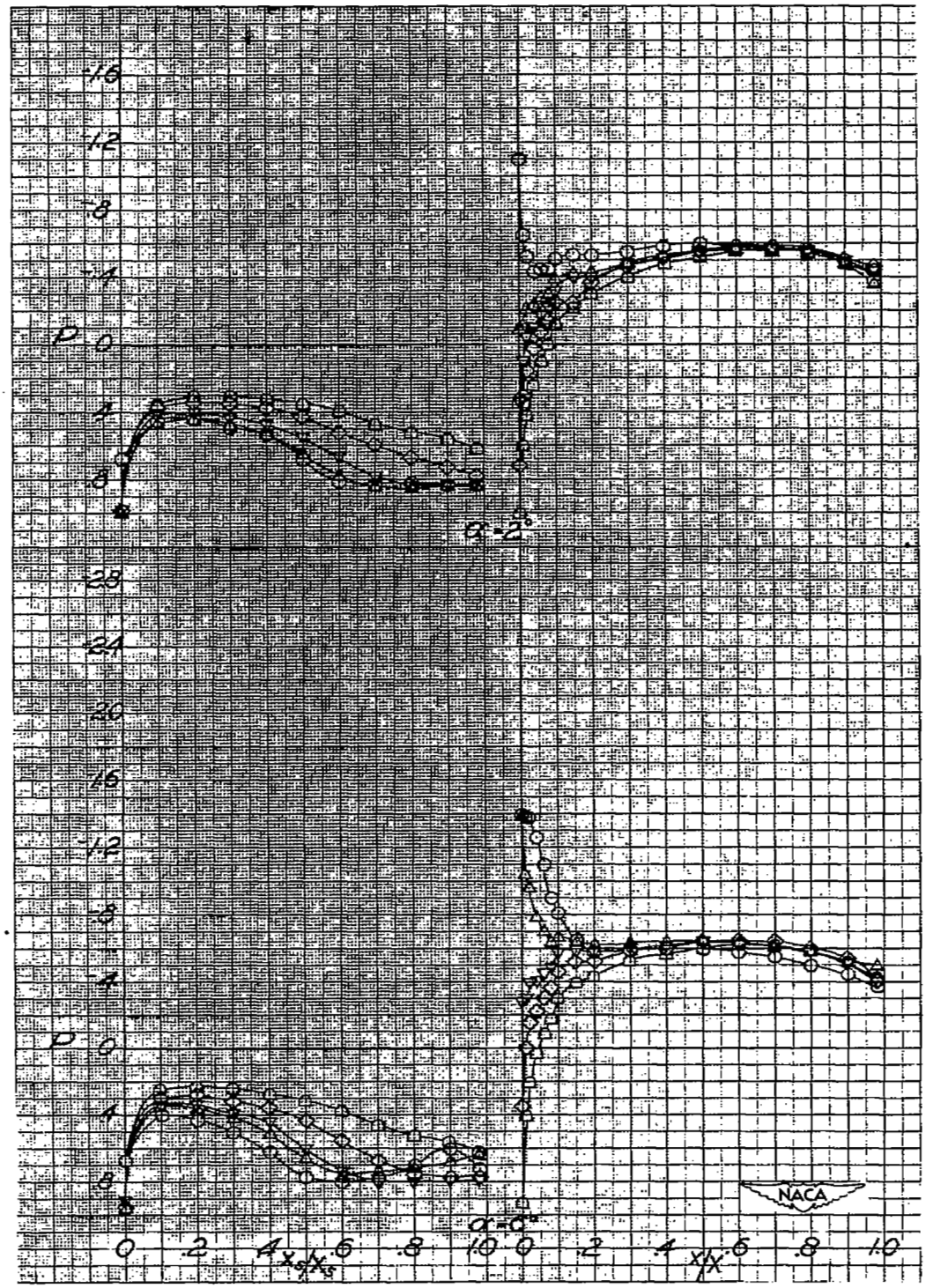


Figure 2.- Concluded.

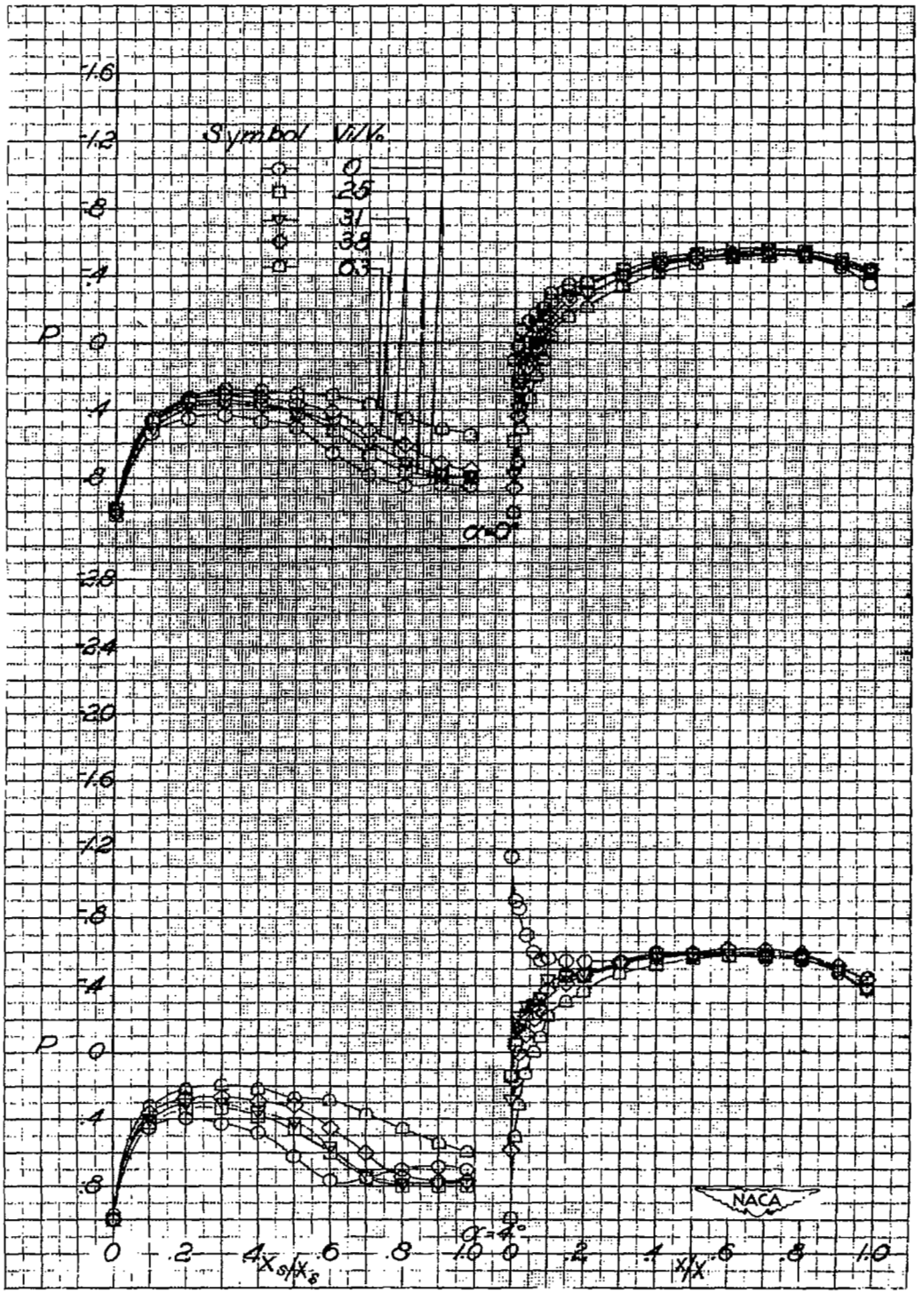
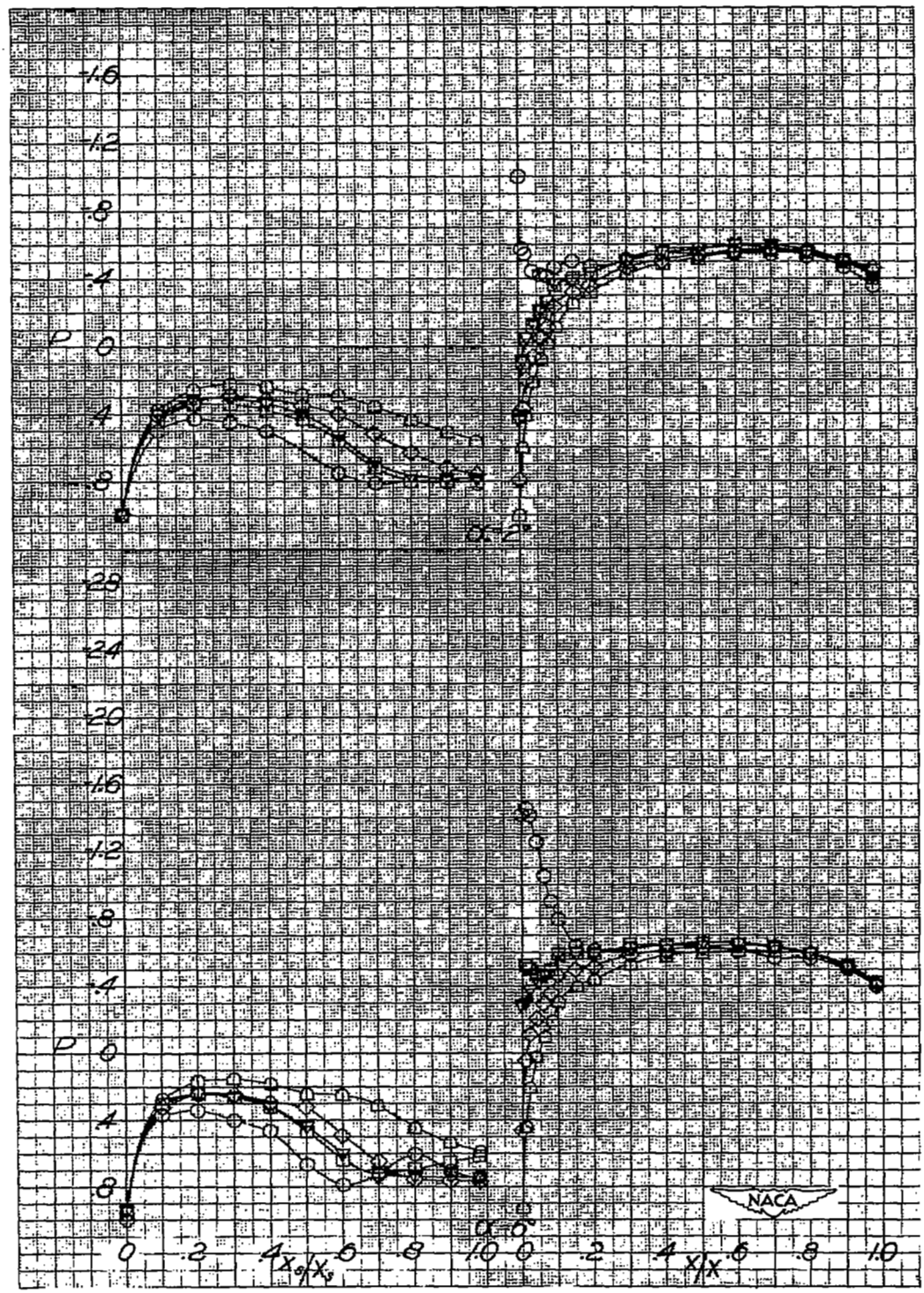


Figure 3.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-30-040 spinner.



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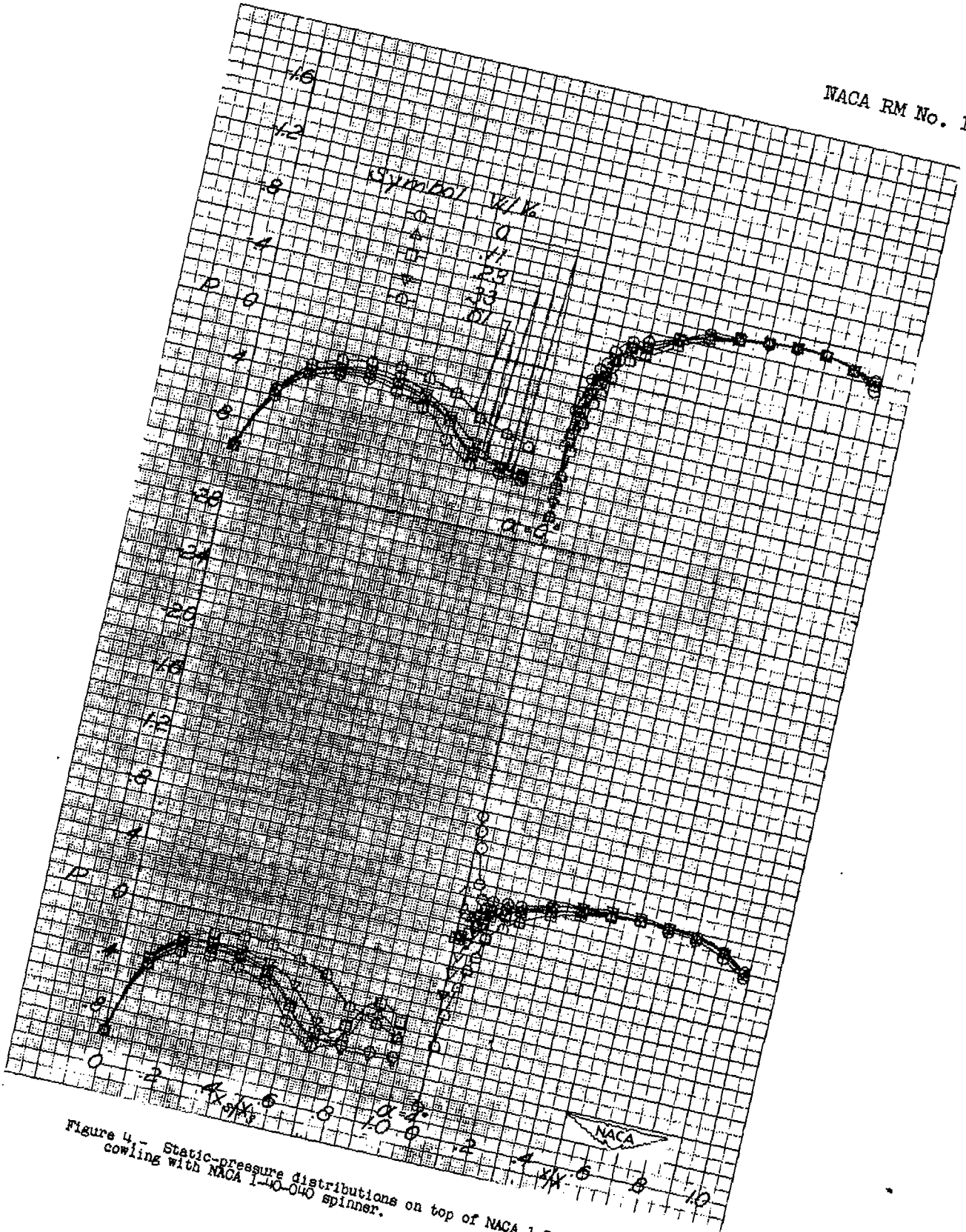


Figure 4.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-40-040 spinner.

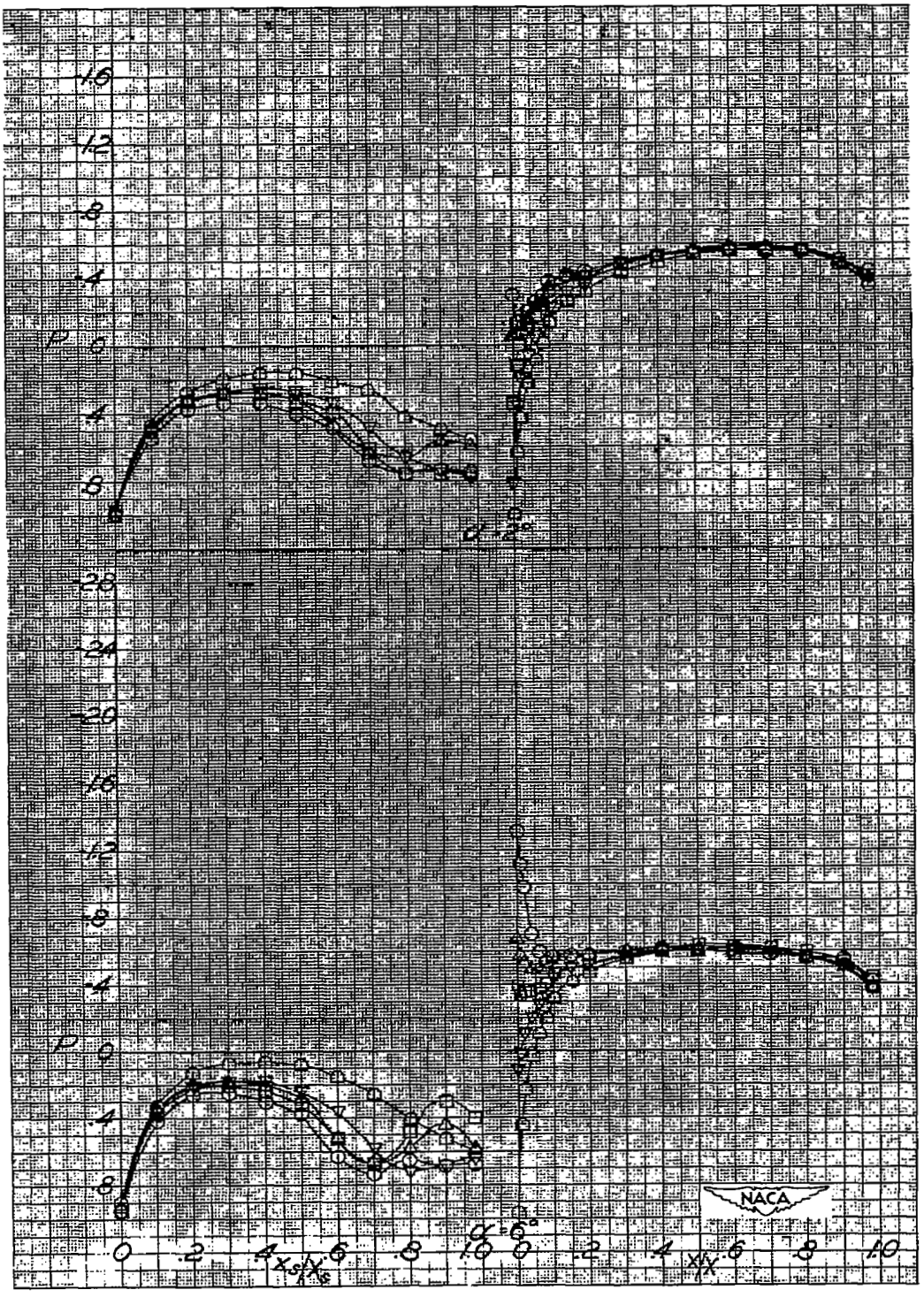


Figure 4.- Concluded.

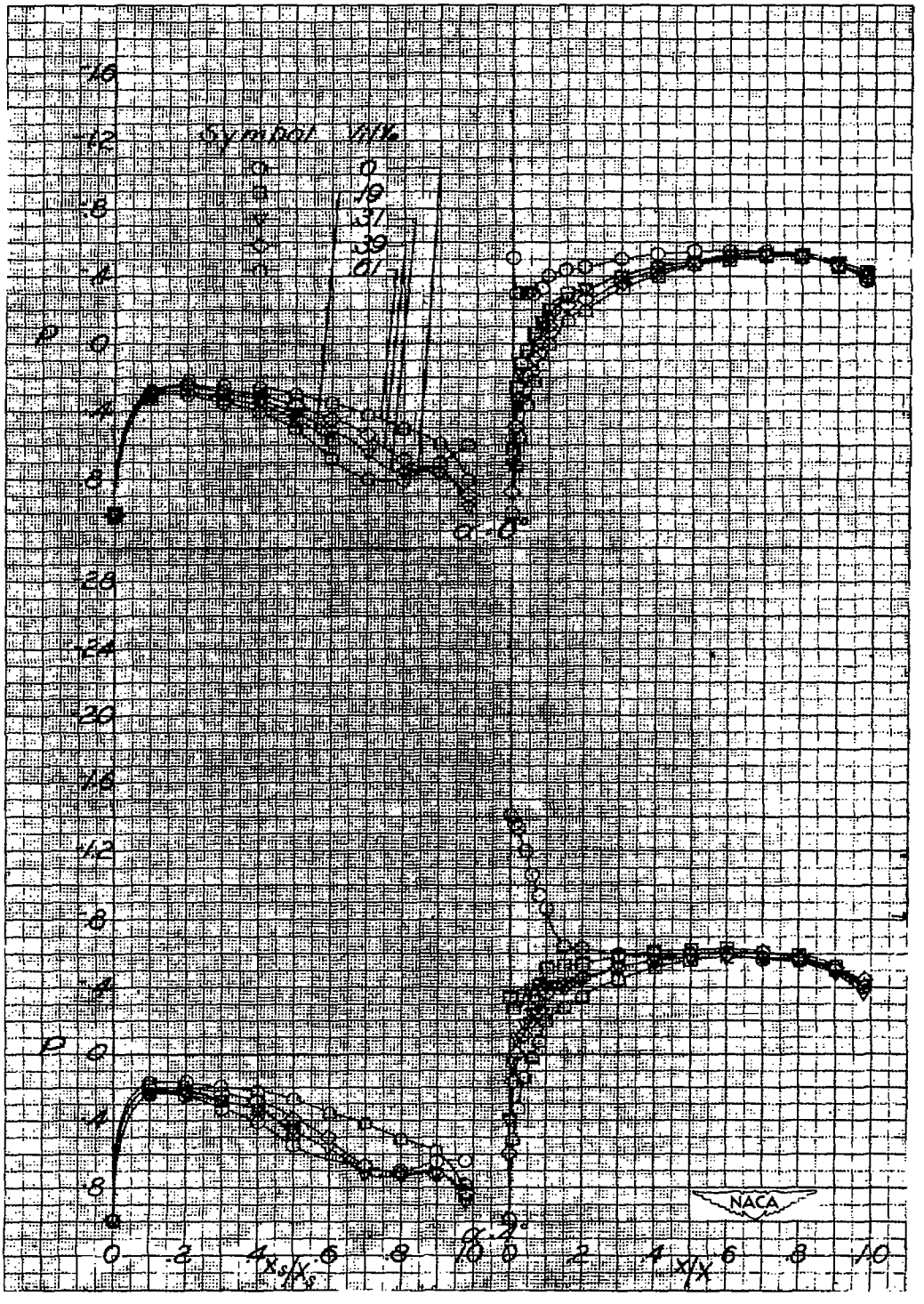


Figure 5.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-20-060 spinner.

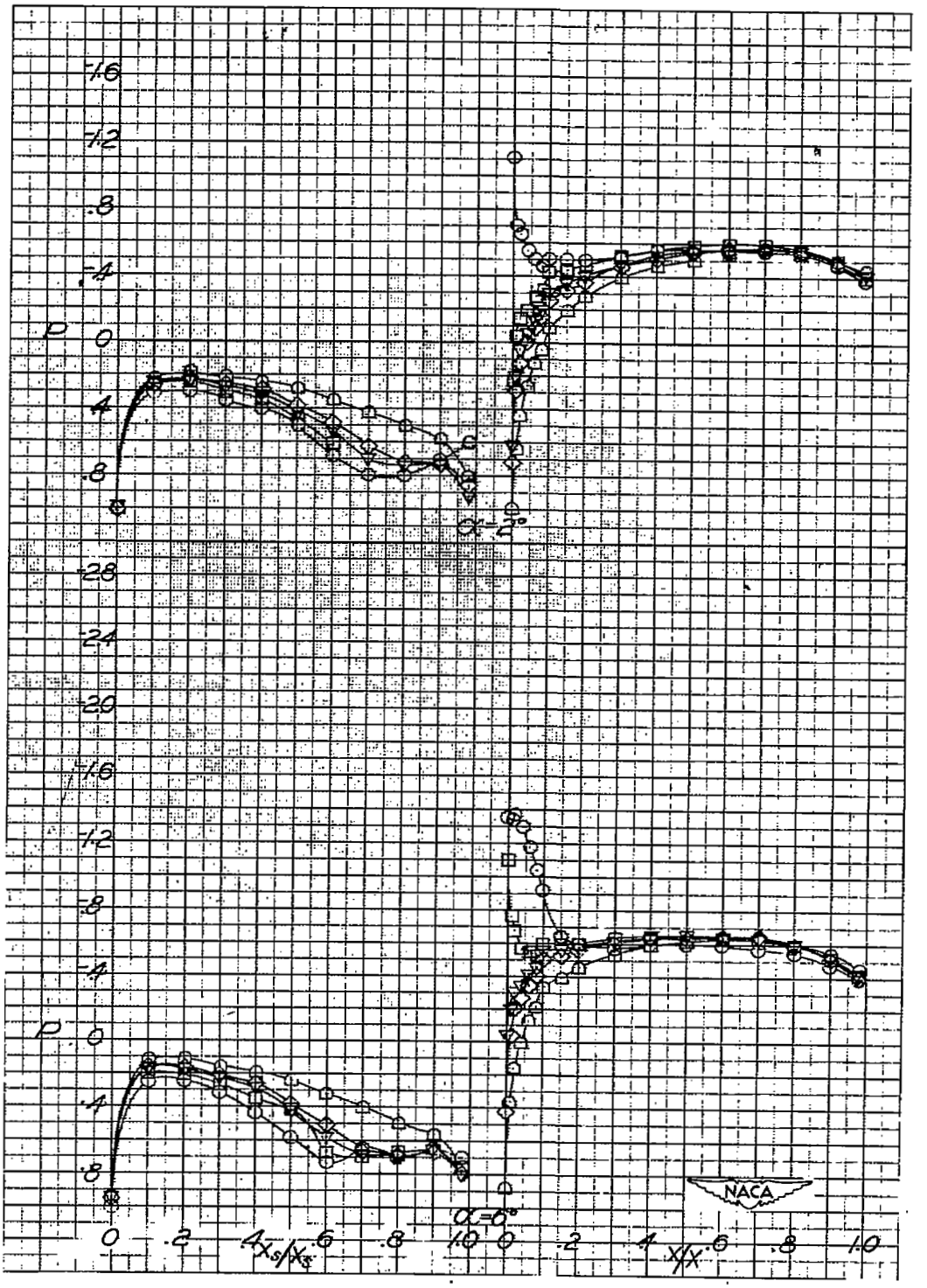


Figure 5.- Concluded.

Figure 6.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-30-060 spinner.

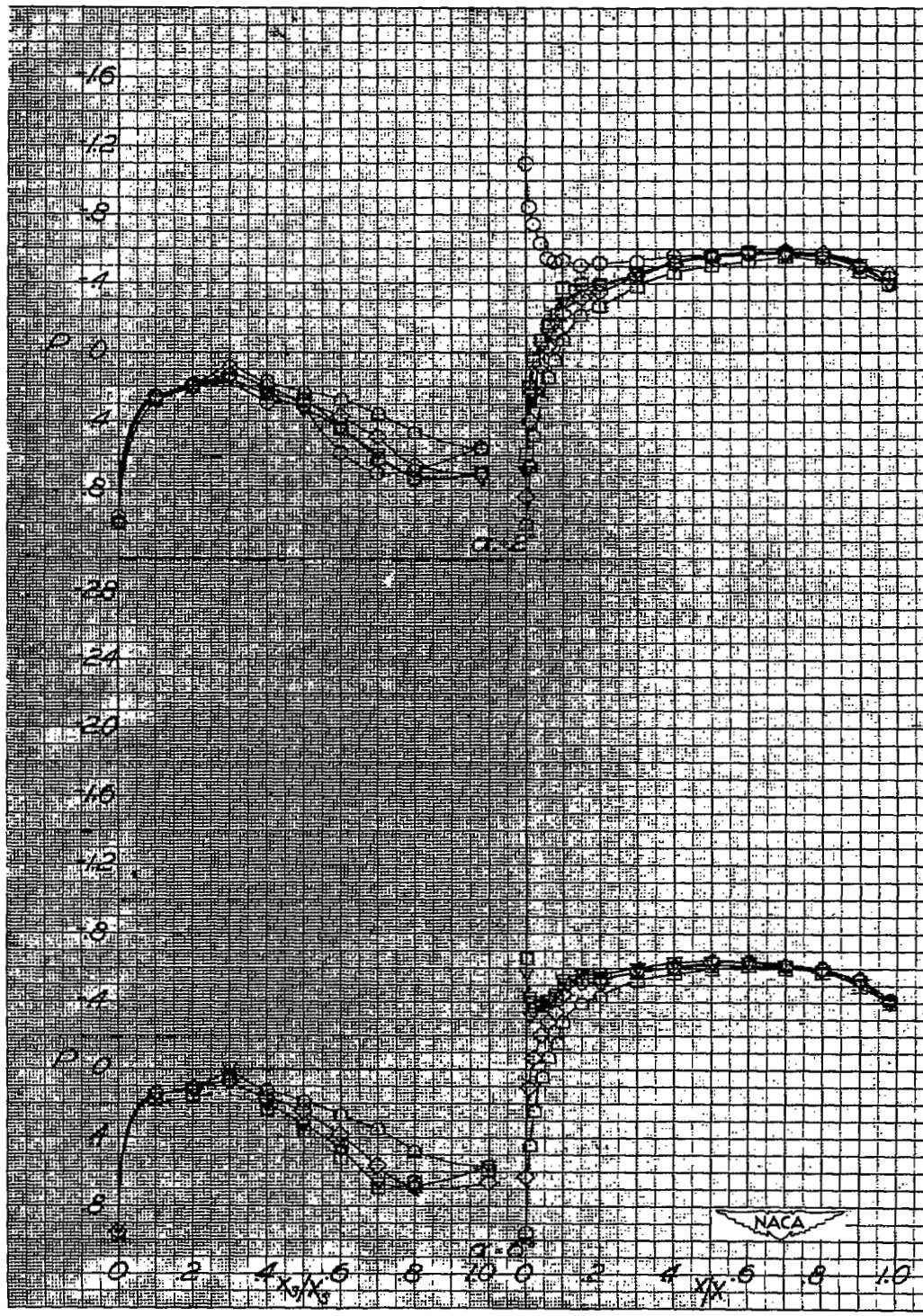


Figure 6.- Concluded.

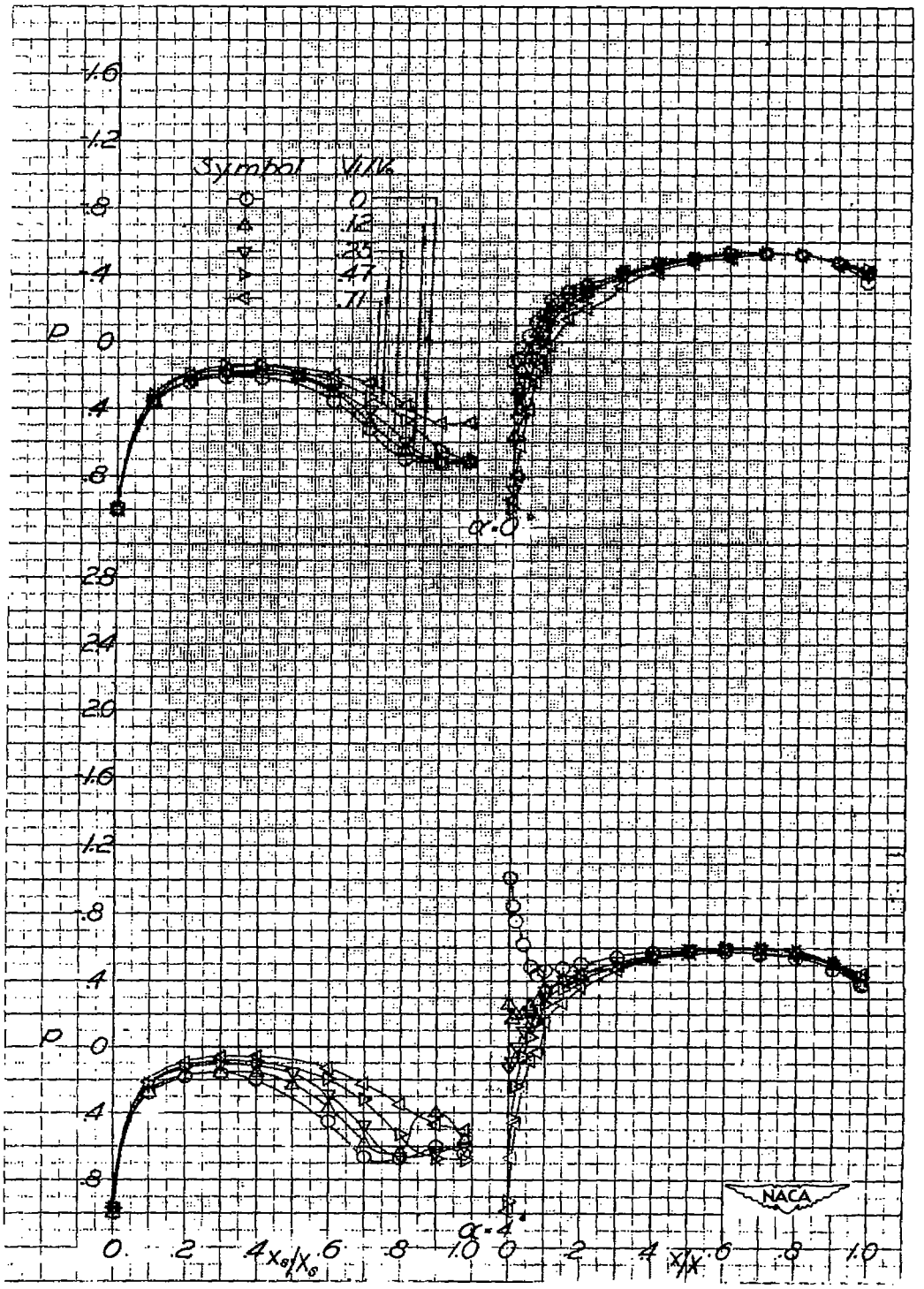


Figure 7.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-40-060 spinner.

Figure 7.- Concluded.

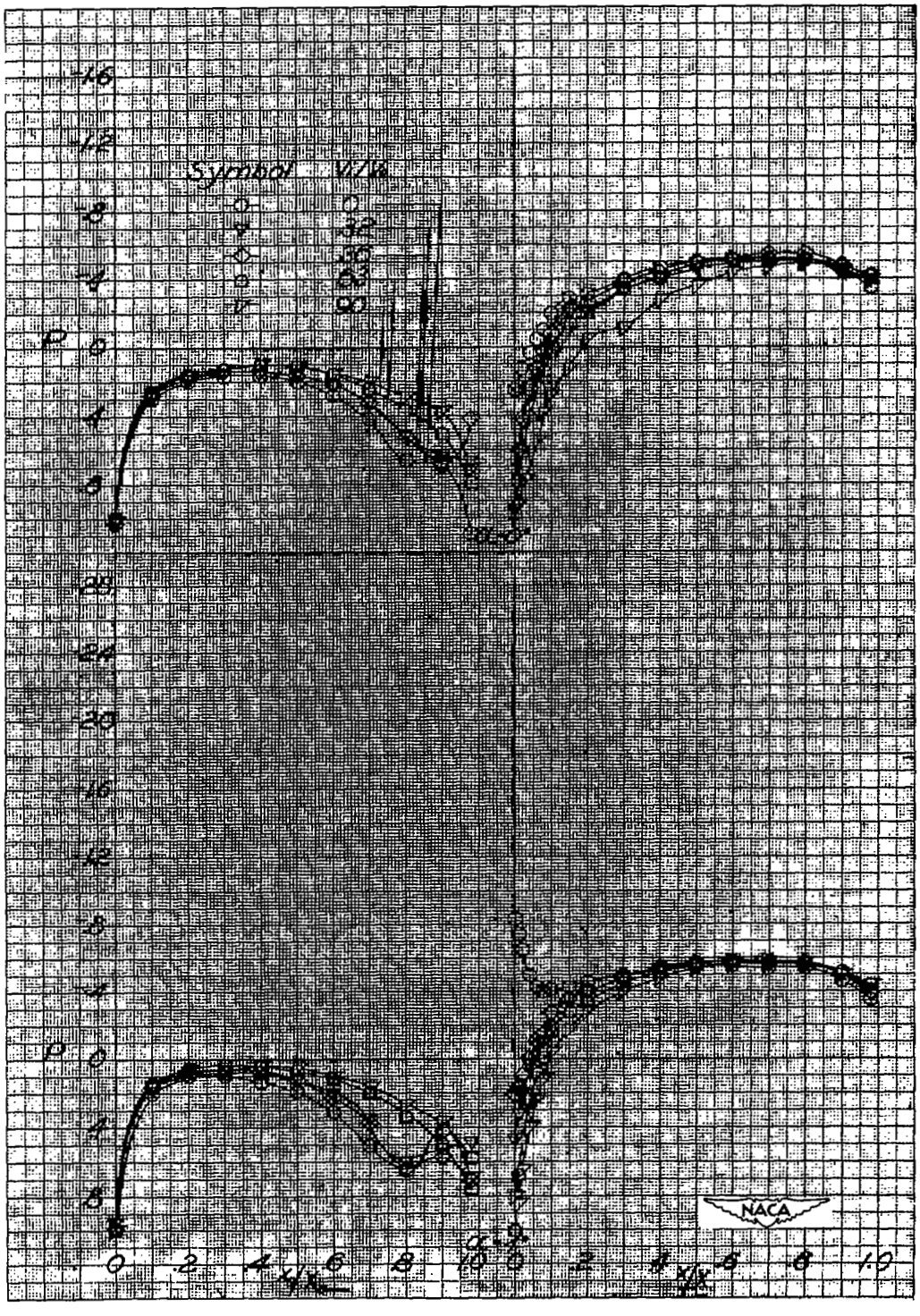


Figure 8.- Static-pressure distributions on top of NACA 1-55-050 cowling with NACA 1-40-080 spinner.

Figure 8.- Concluded.

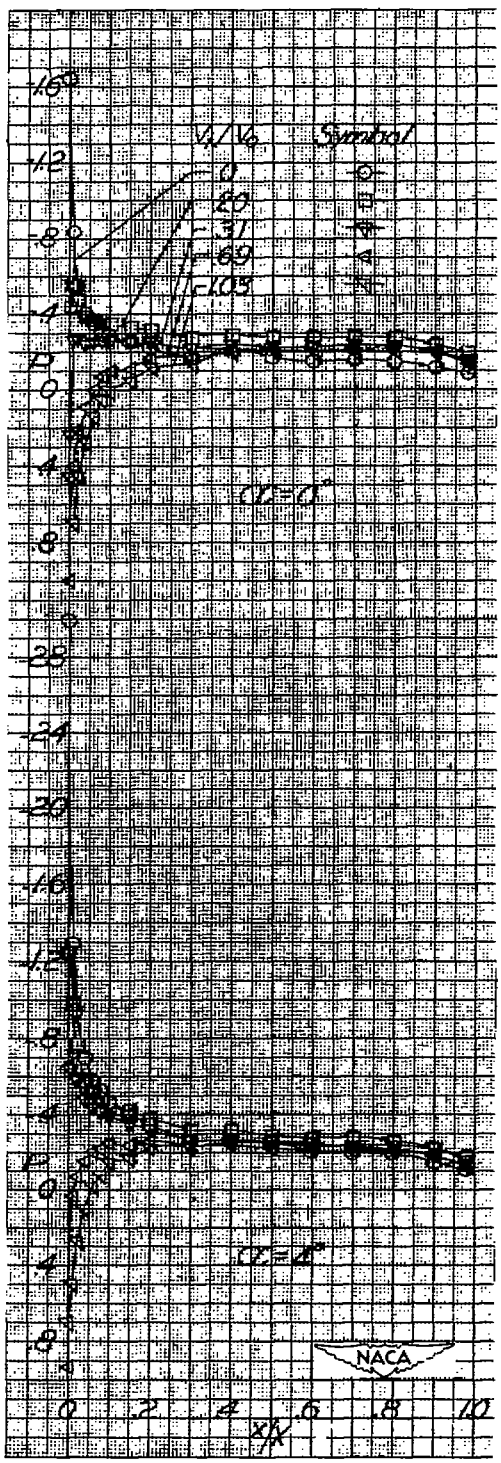


Figure 9.- Static-pressure distributions on top of NACA 1-55-100 open-nose cowling.

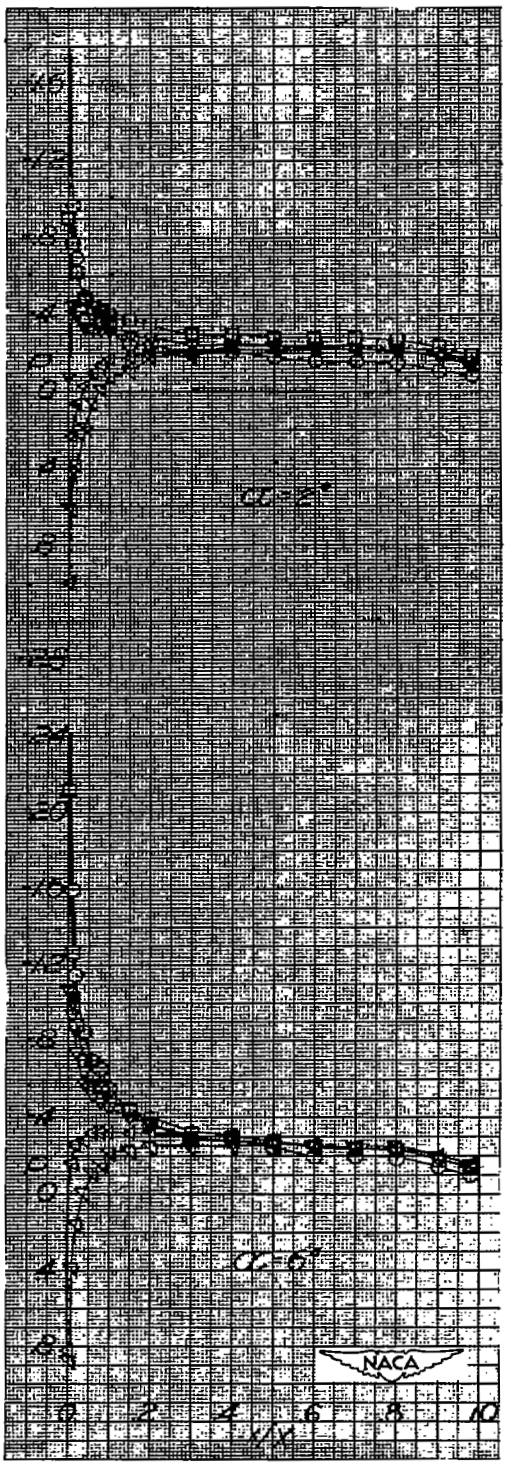


Figure 9.- Concluded.

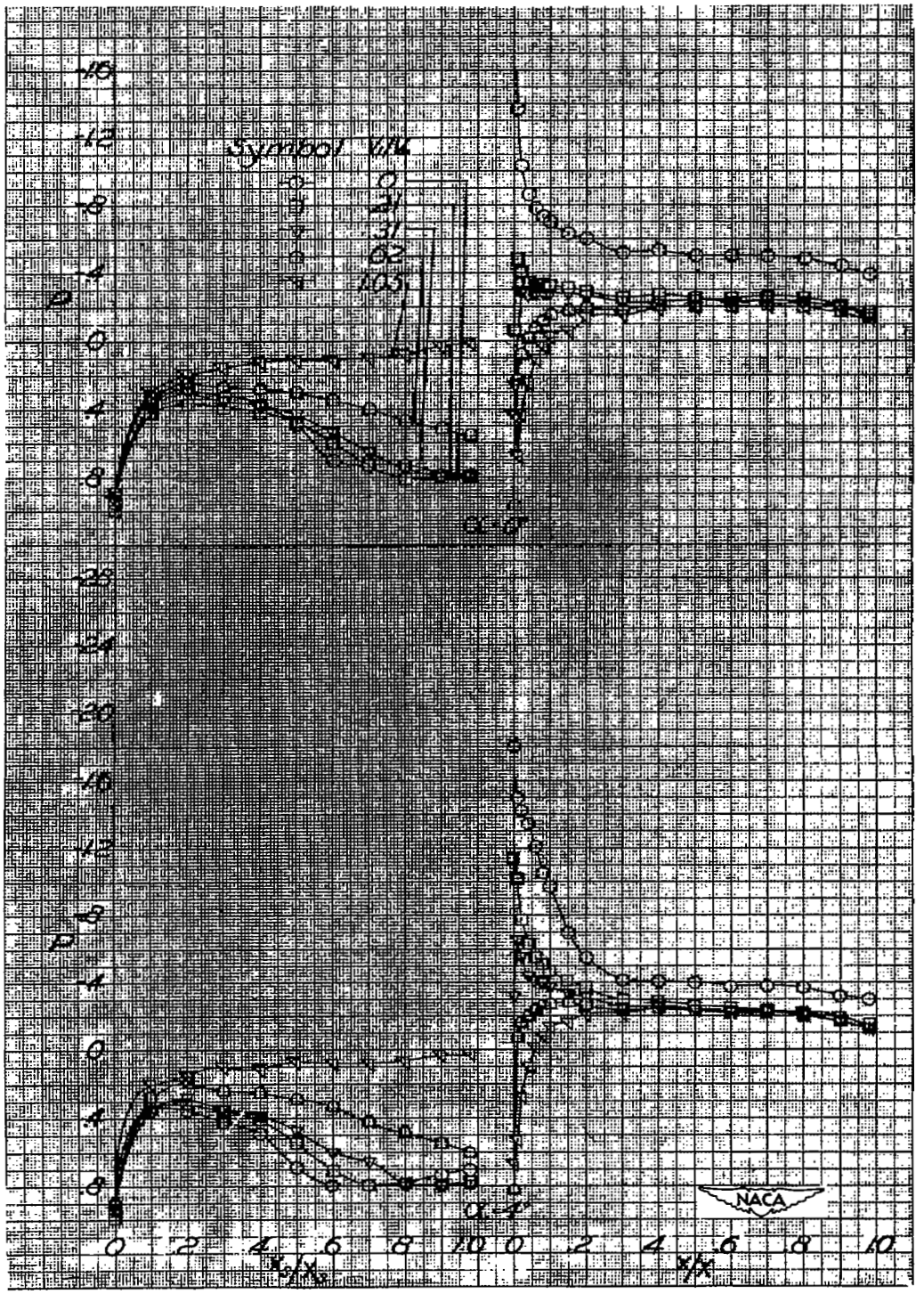


Figure 10.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-20-040 spinner.

Figure 10.- Concluded.

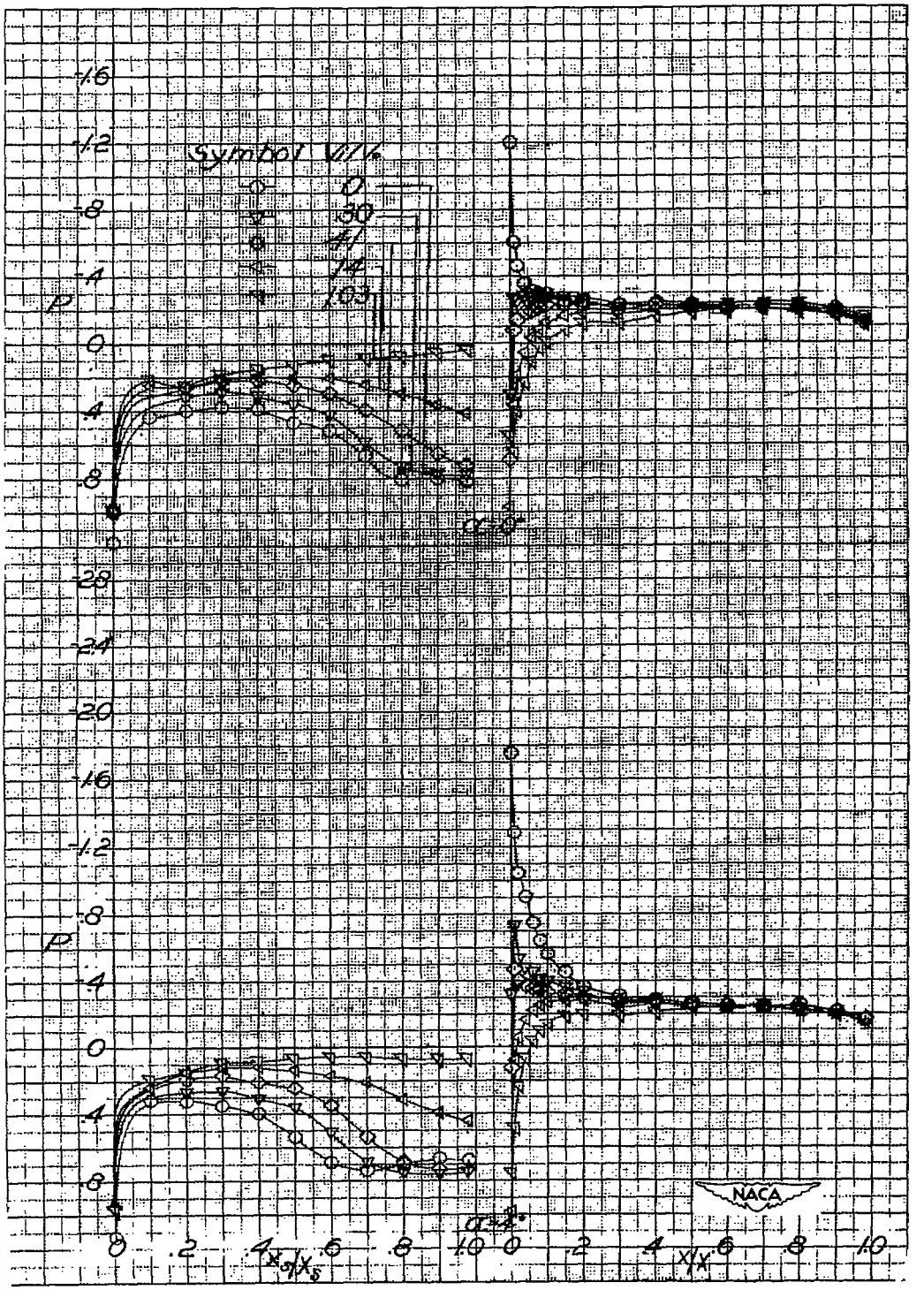


Figure 11.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-30-040 spinner.

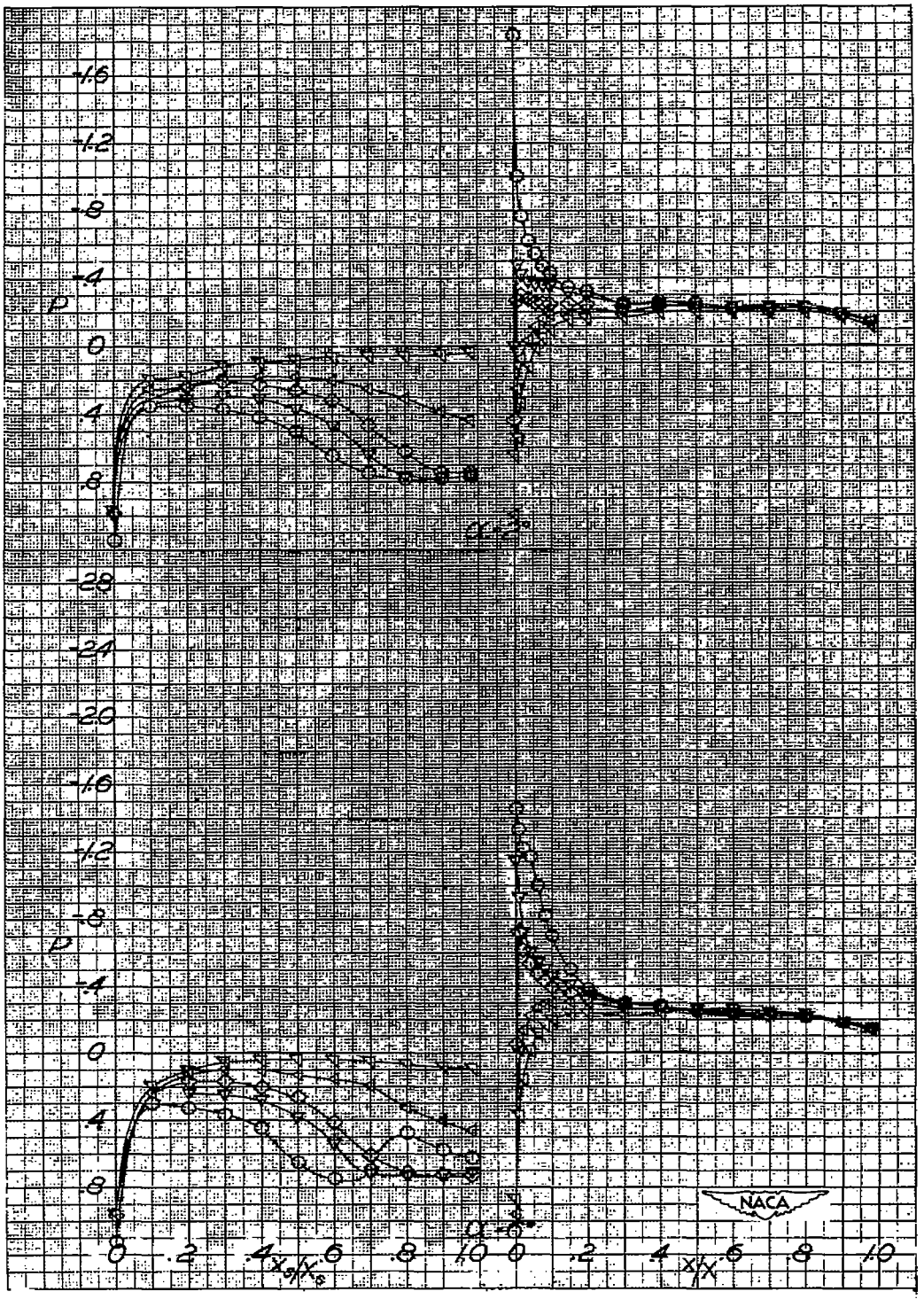


Figure 11.- Concluded.

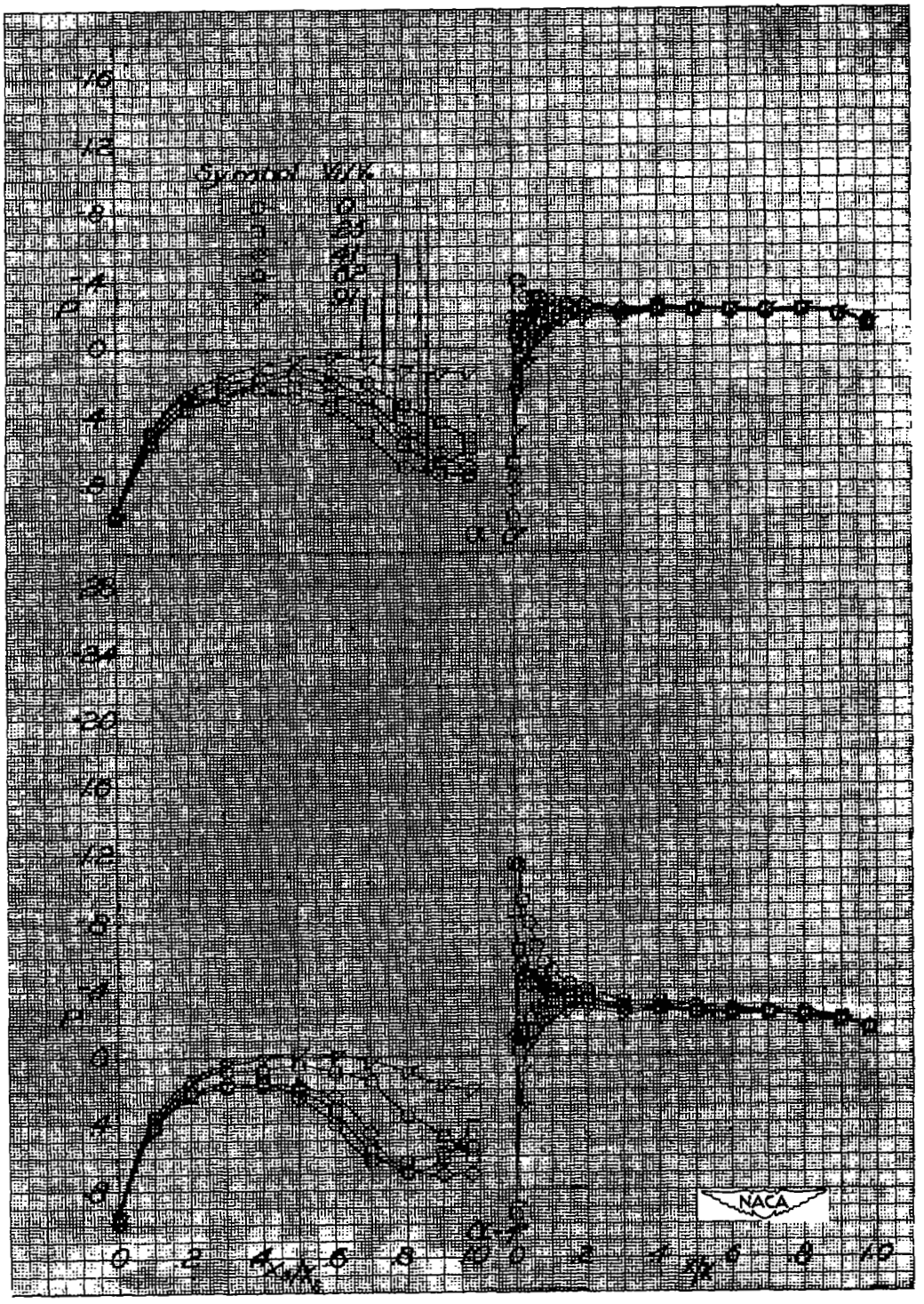


Figure 12.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-40-040 spinner.

Figure 12.- Concluded.

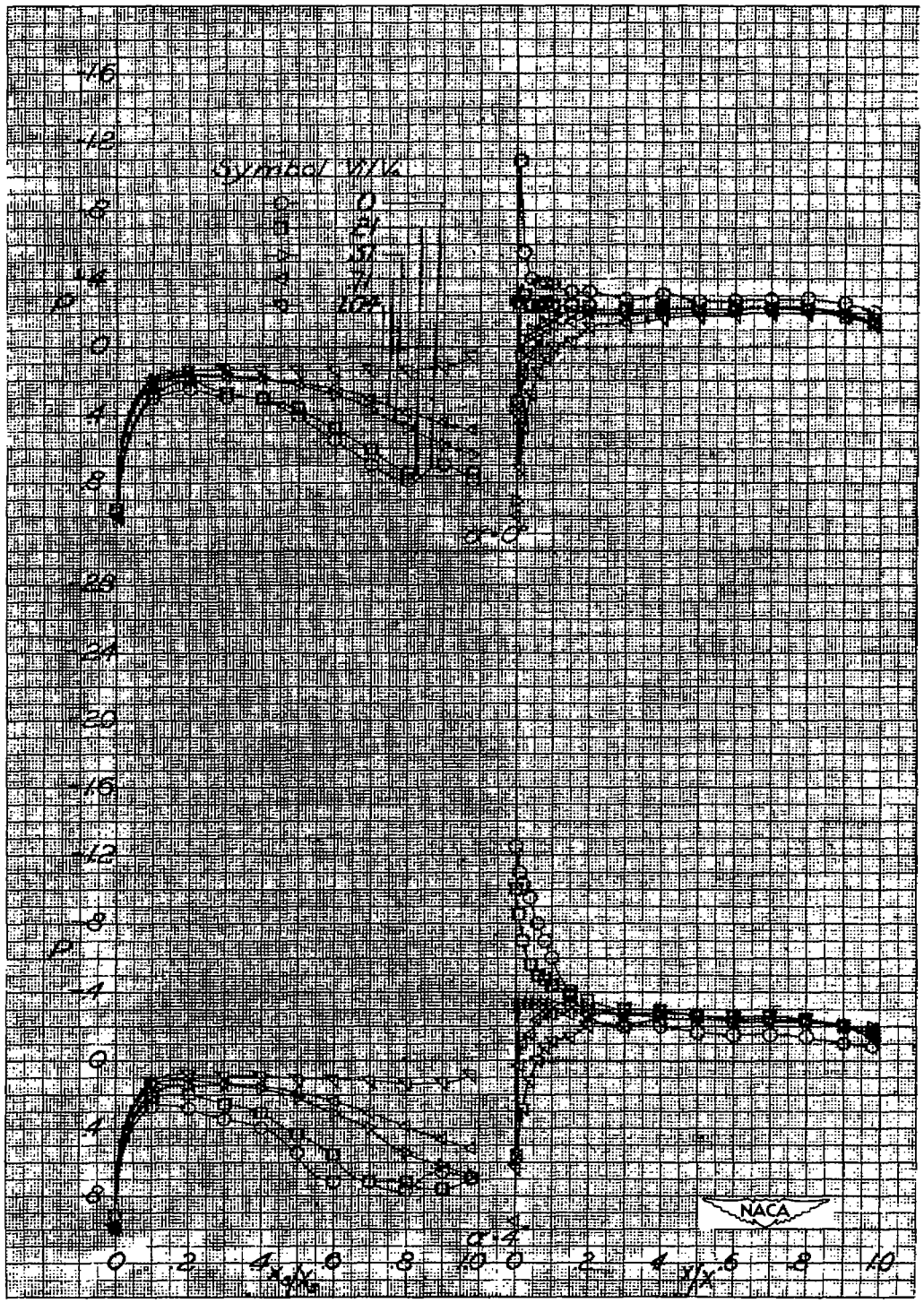


Figure 13.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-20-060 spinner.

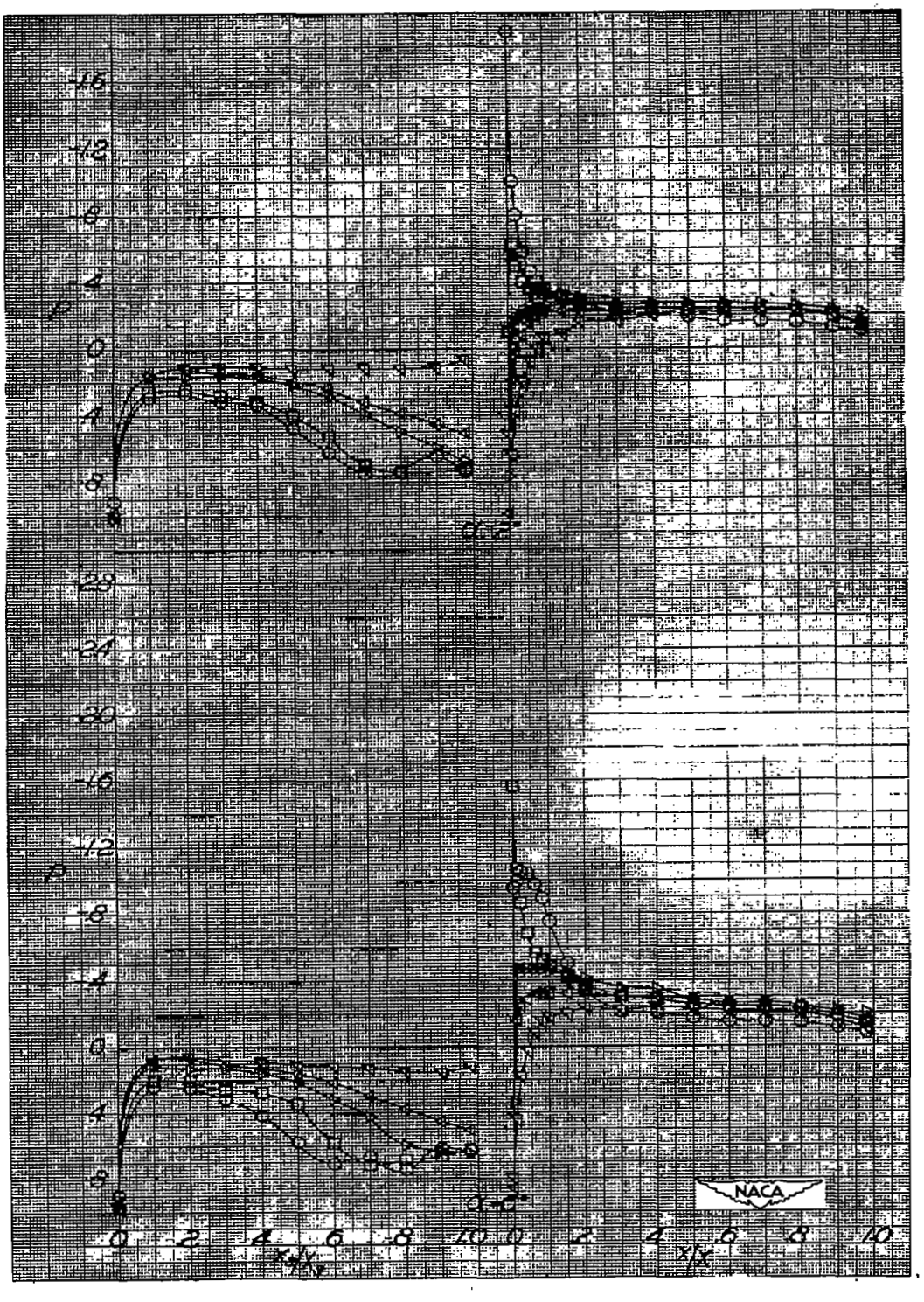


Figure 13.- Concluded.

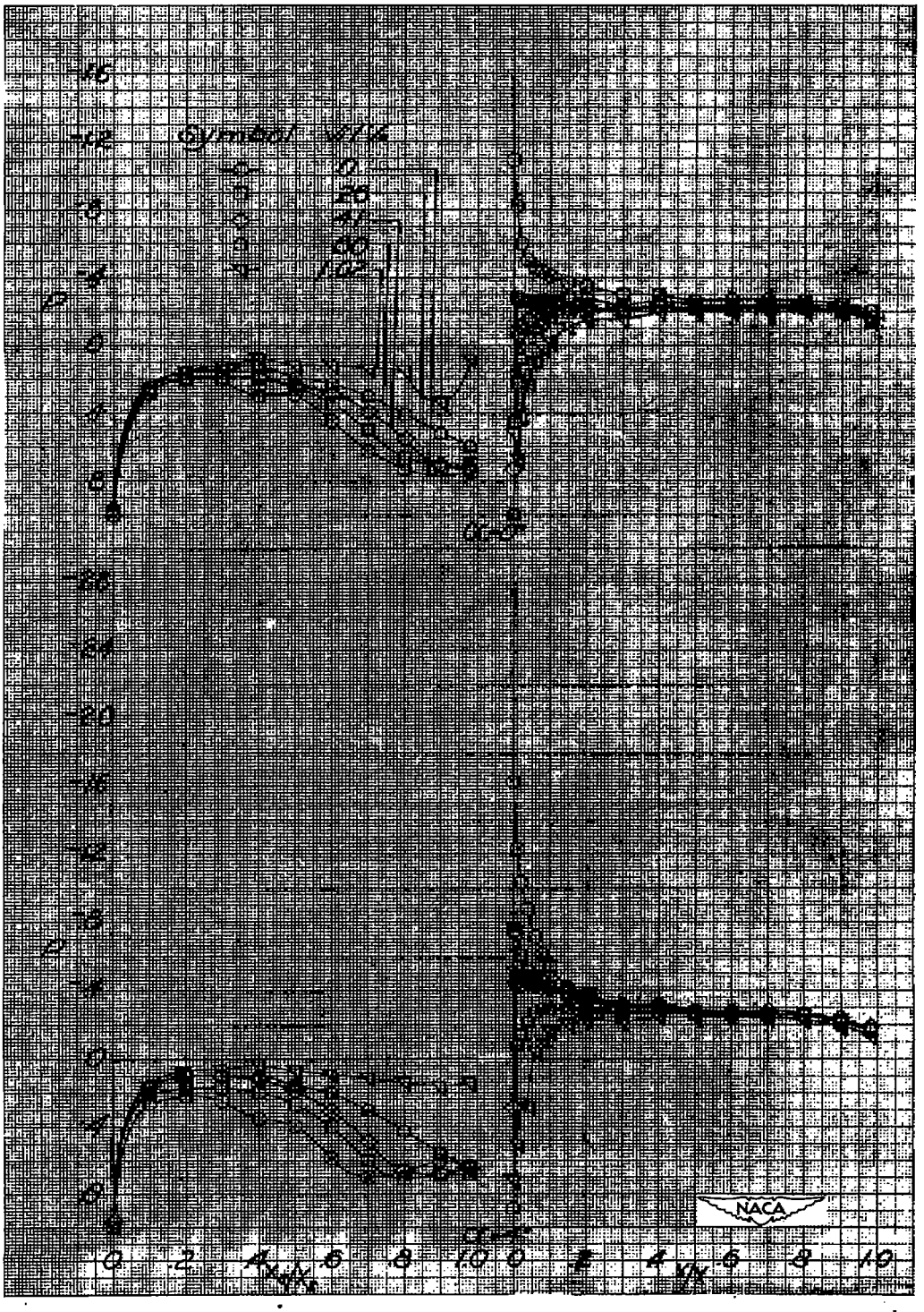


Figure 14.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-30-060 spinner.

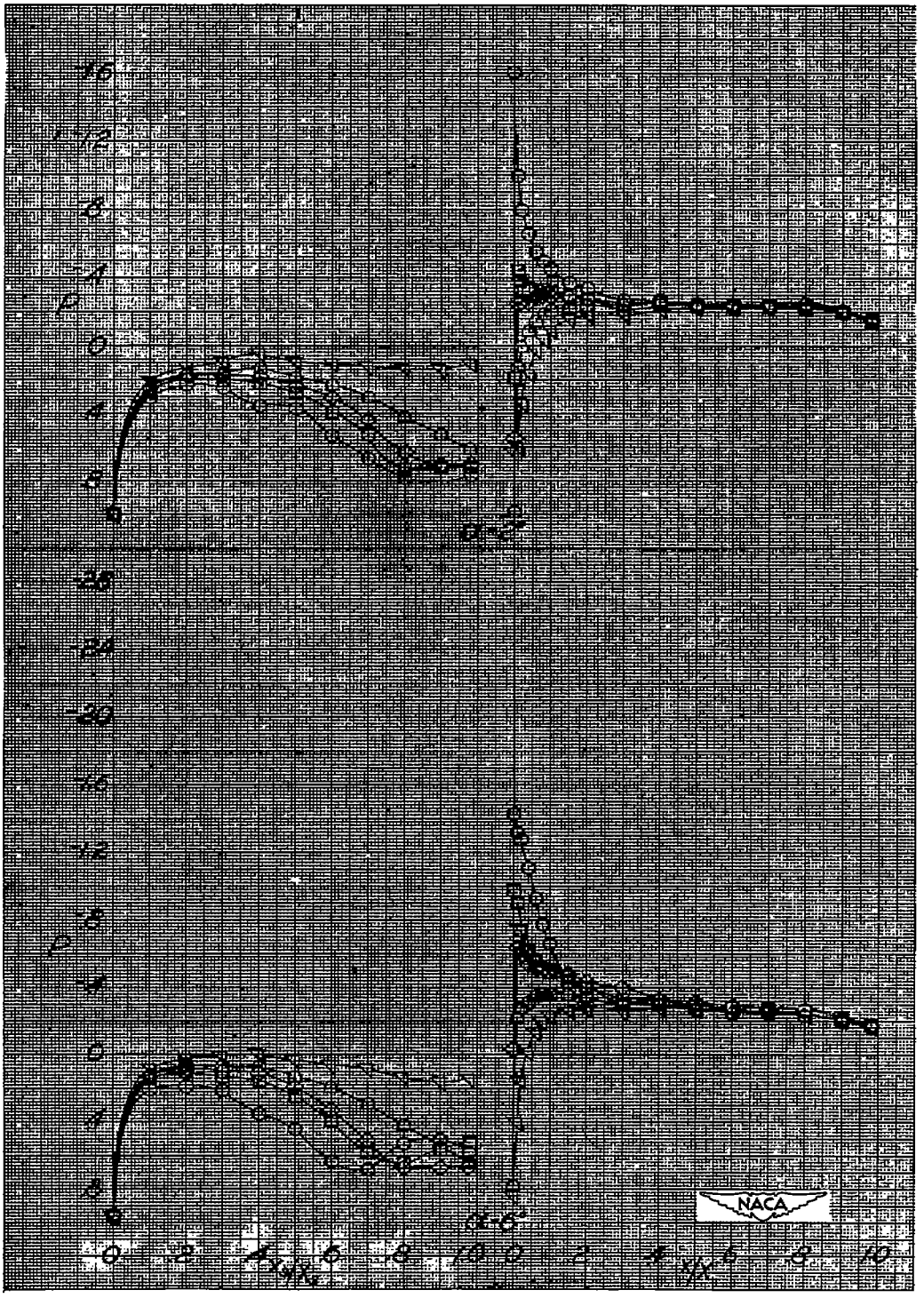


Figure 14.- Concluded.

Figure 15.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-40-060 spinner.

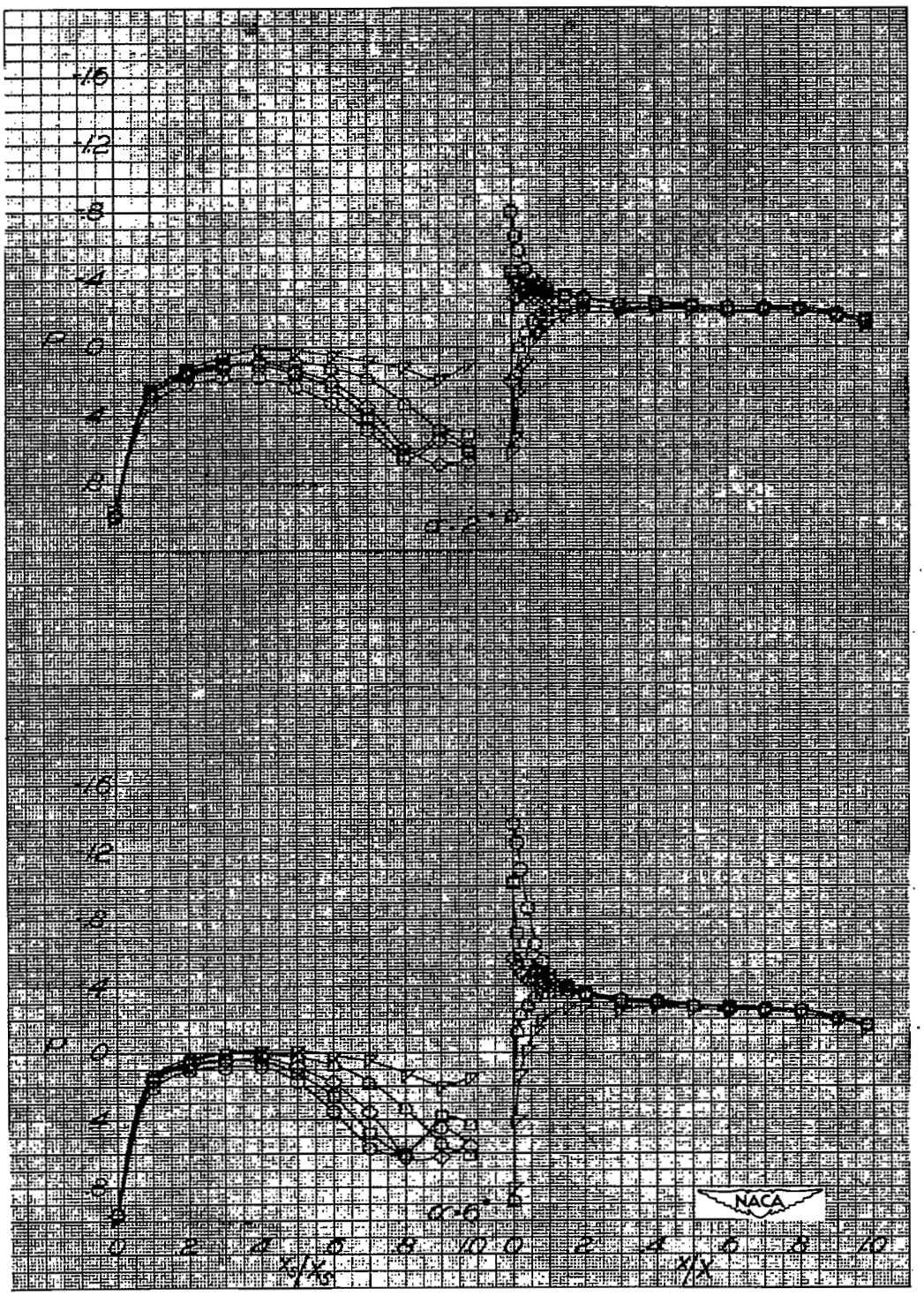


Figure 15.- Concluded.

Figure 16.- Static-pressure distributions on top of NACA 1-55-100 cowling with NACA 1-40-080 spinner.

Figure 16.- Concluded.

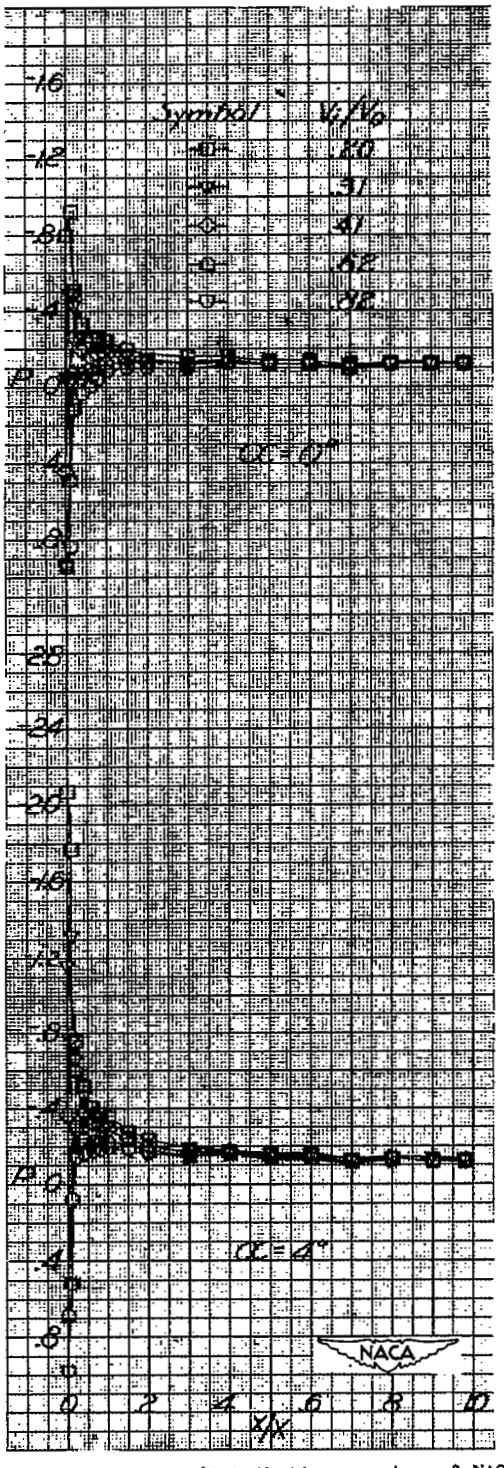


Figure 17.- Static-pressure distributions on top of NACA 1-55-150 open-nose cowling.

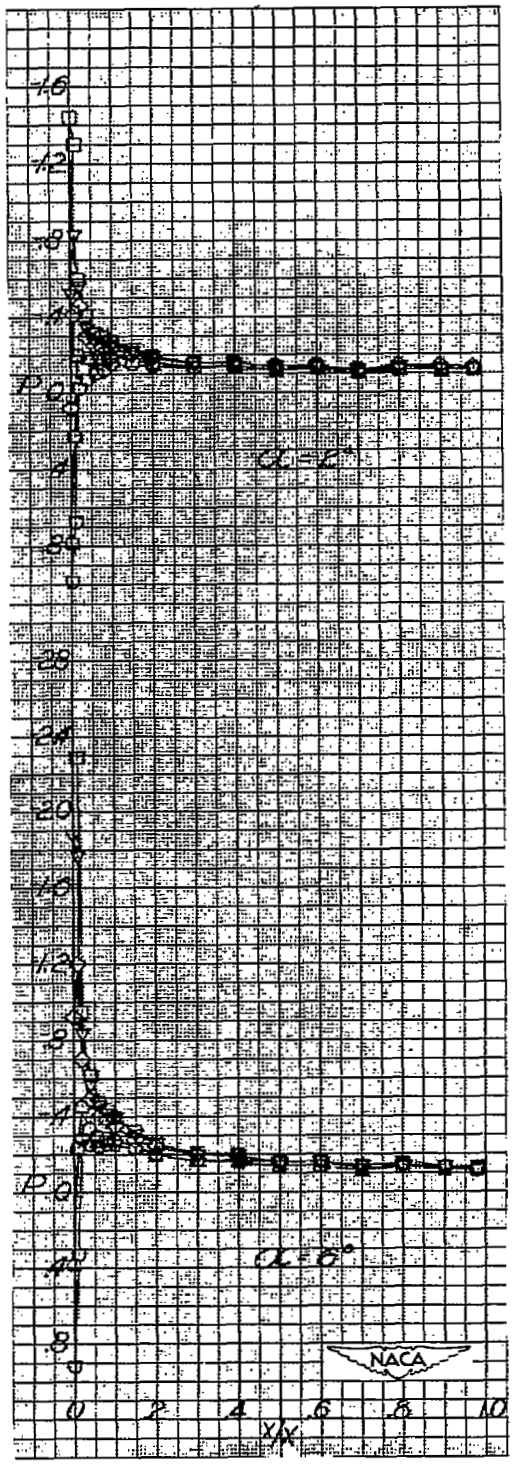


Figure 17.- Concluded.

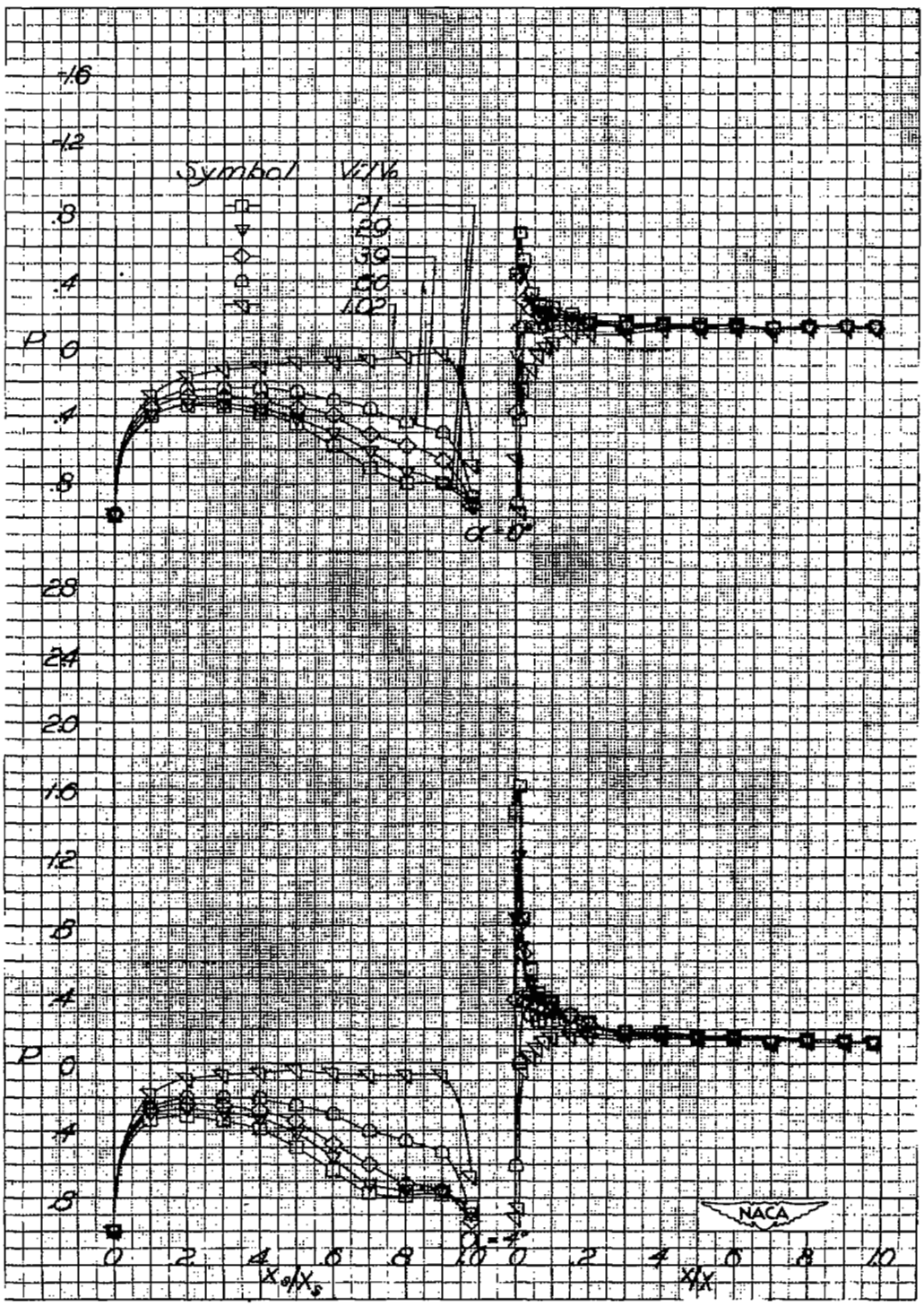


Figure 18.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-20-040 spinner.

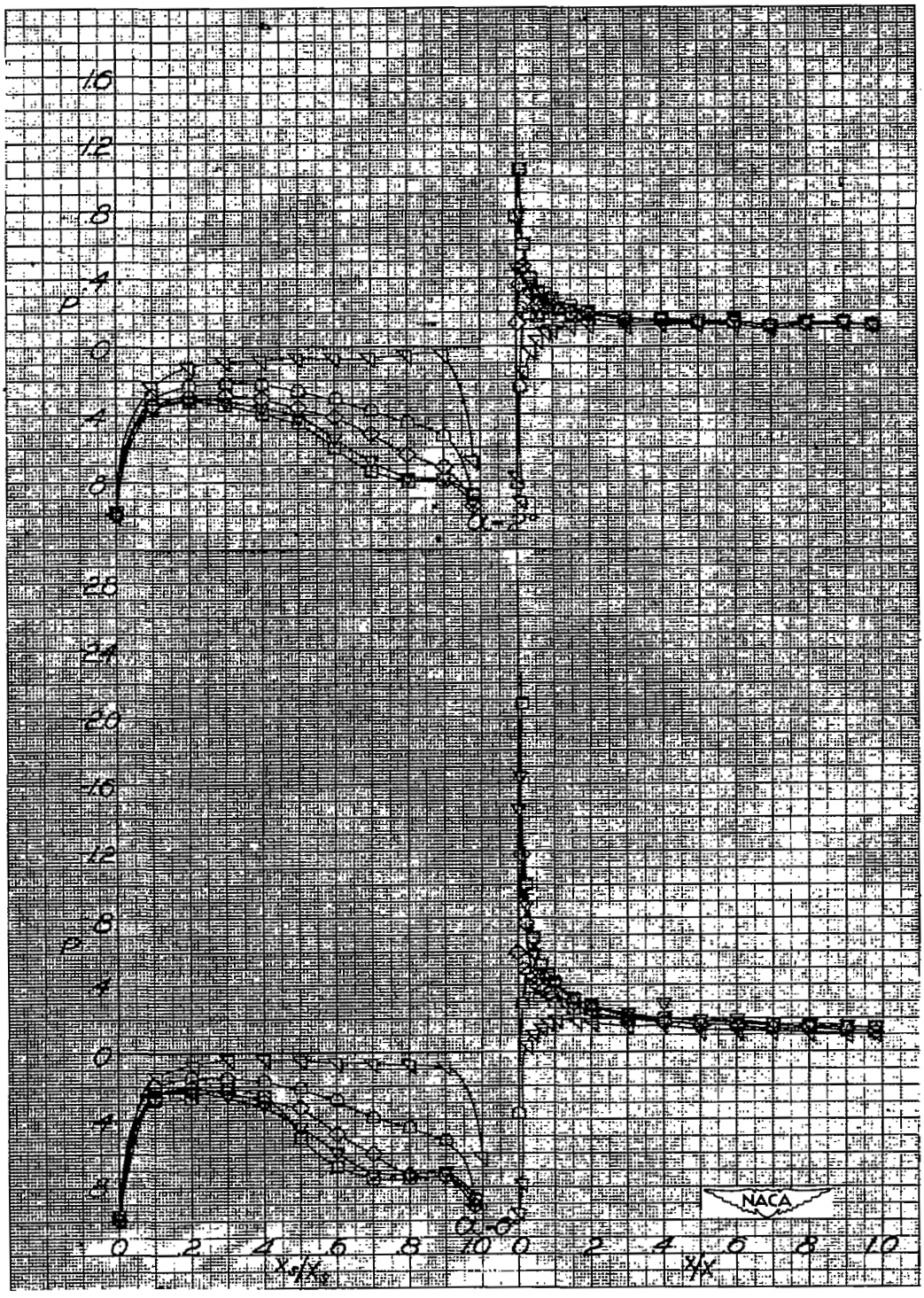


Figure 18.- Concluded.

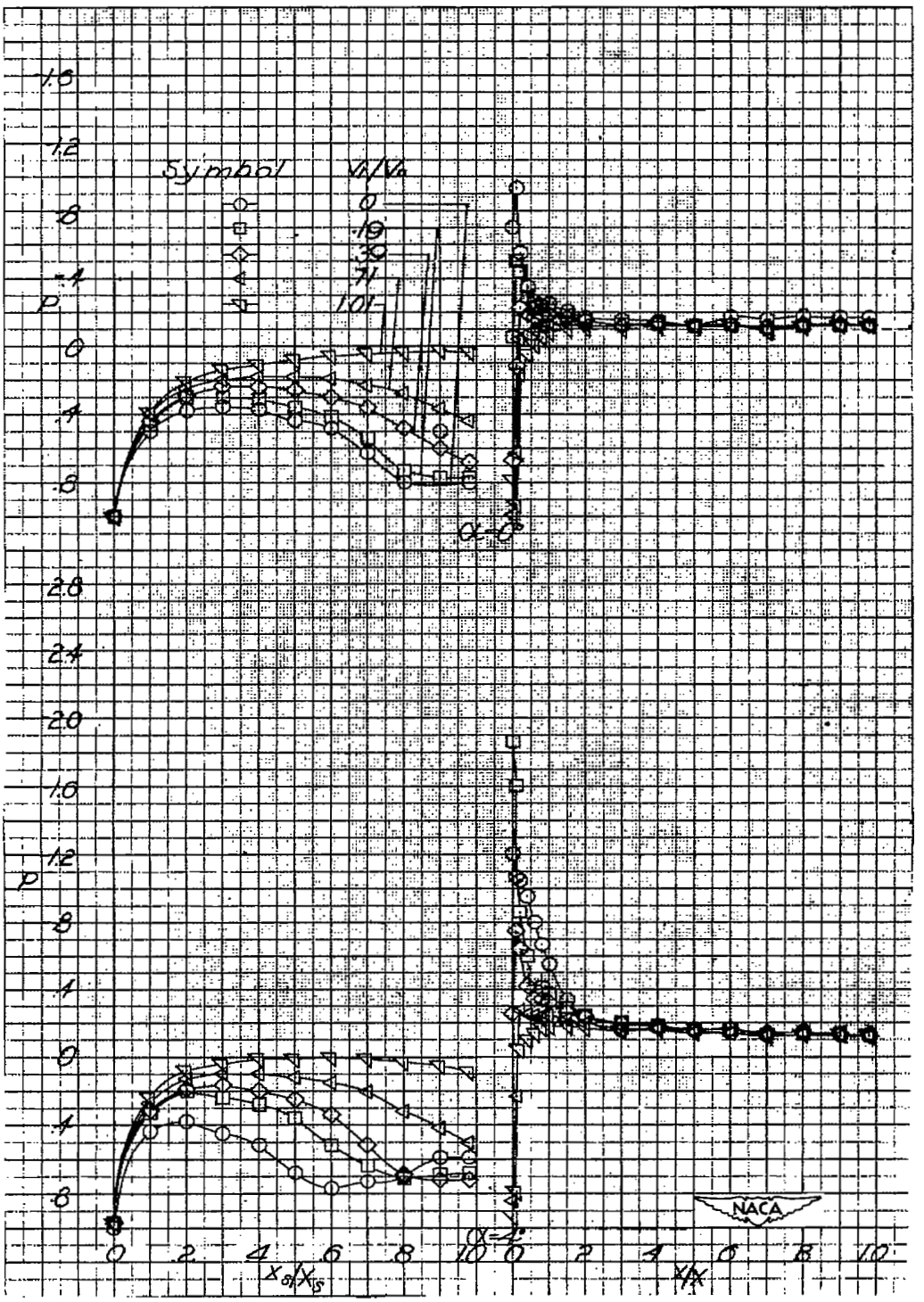


Figure 19.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-30-040 spinner.

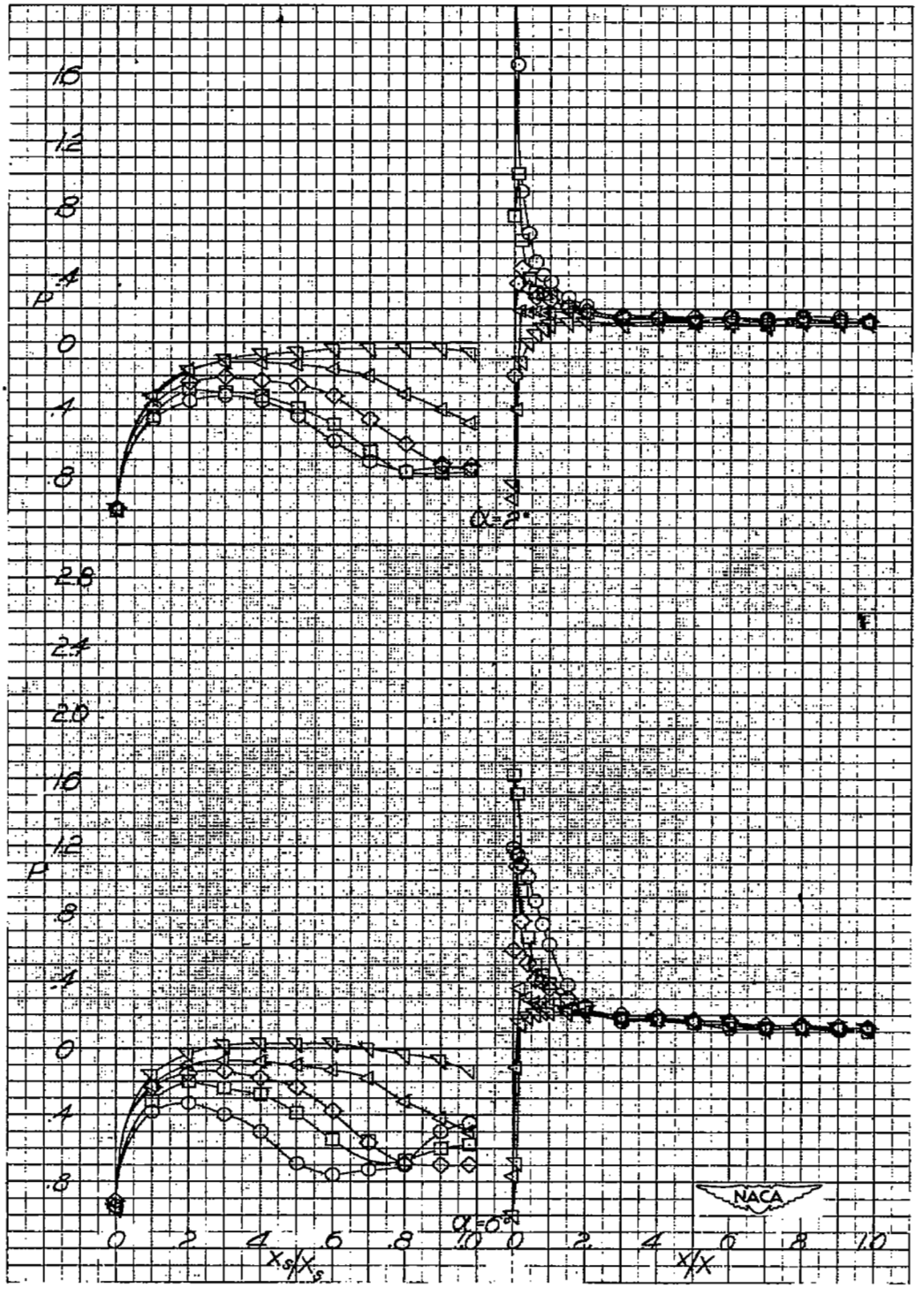
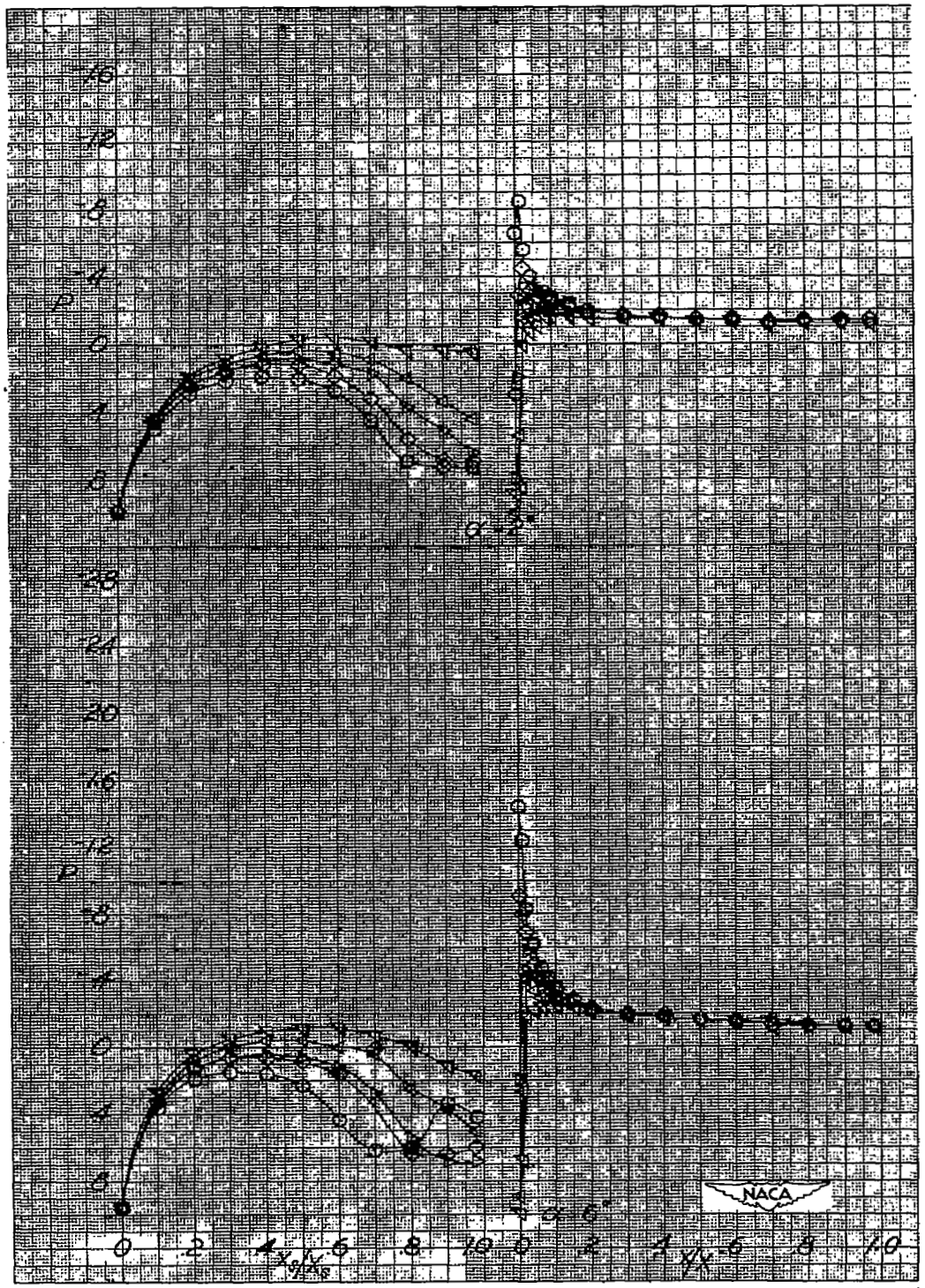


Figure 19.- Concluded.

Figure 20.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-40-040 spinner.



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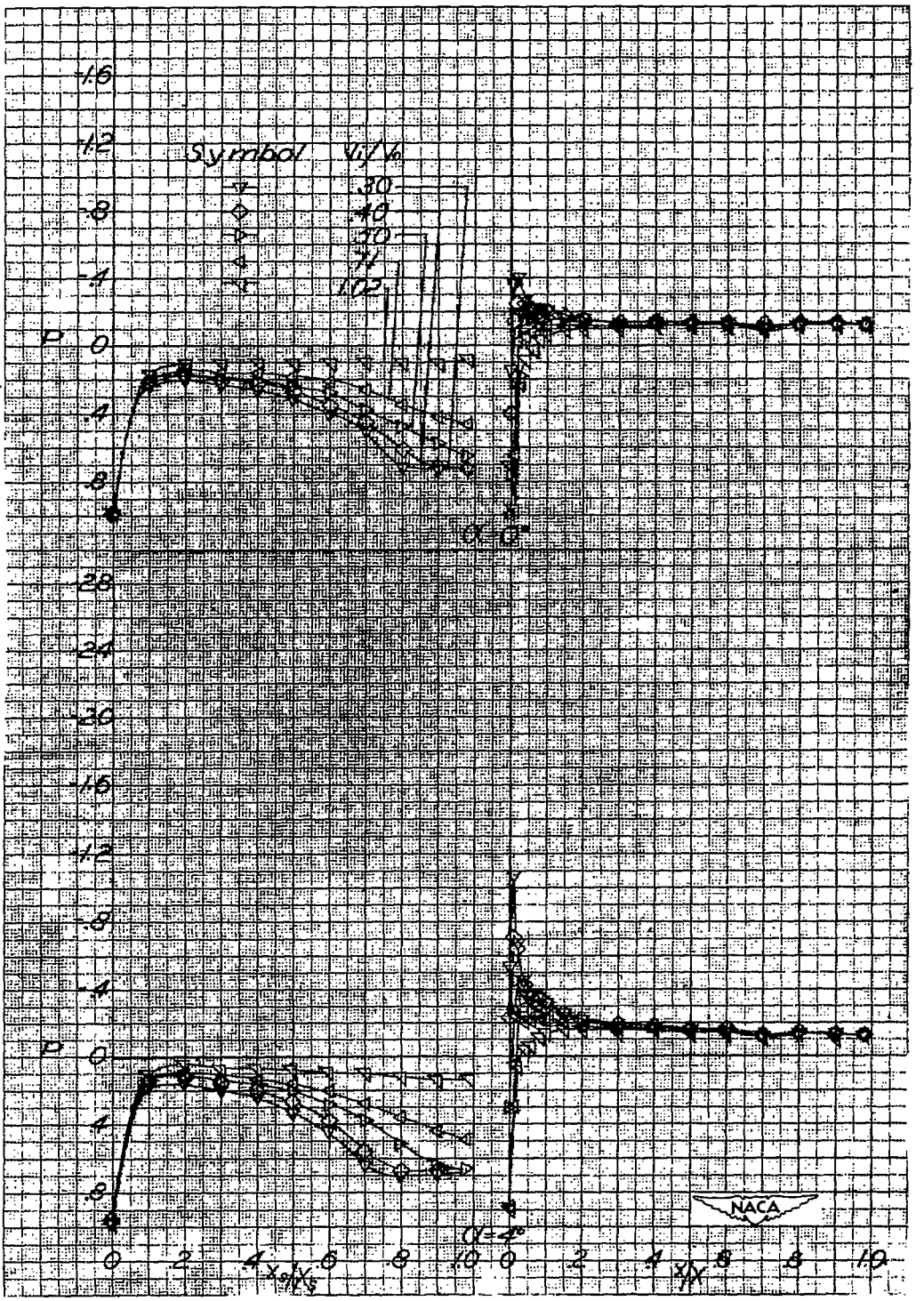


Figure 21.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-20-060 spinner.

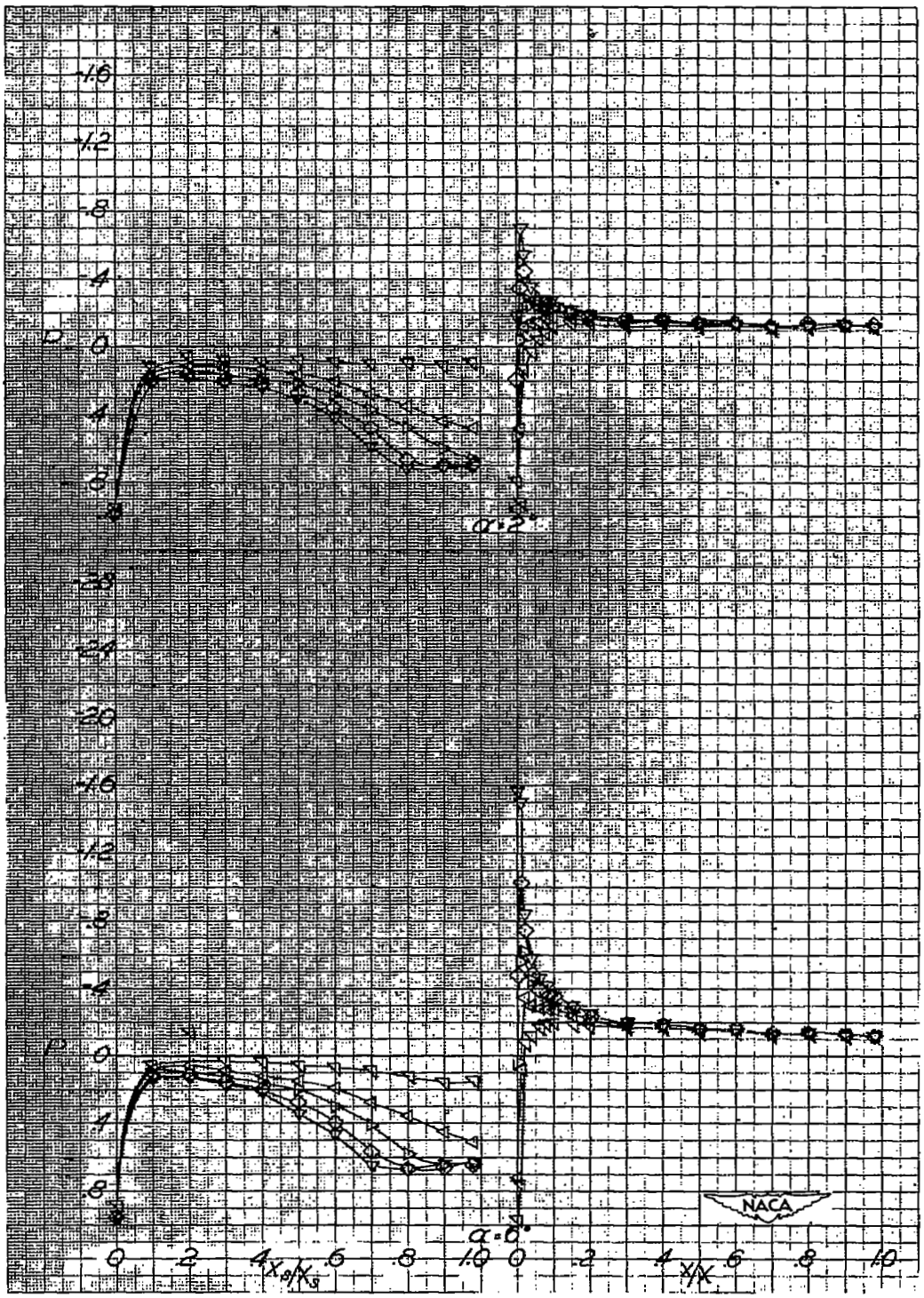


Figure 21.- Concluded.

Figure 22.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-30-060 spinner.

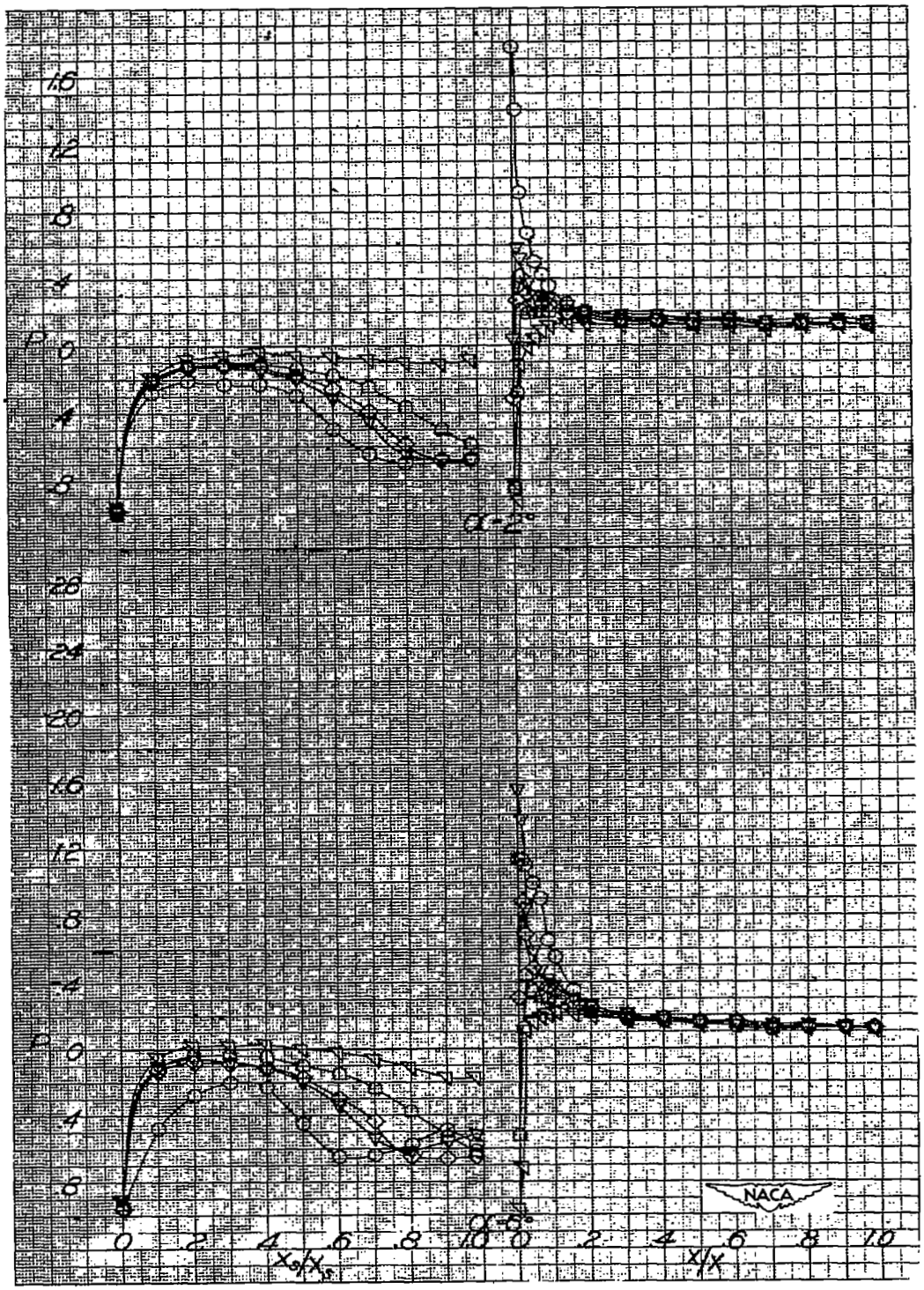


Figure 22.- Concluded.

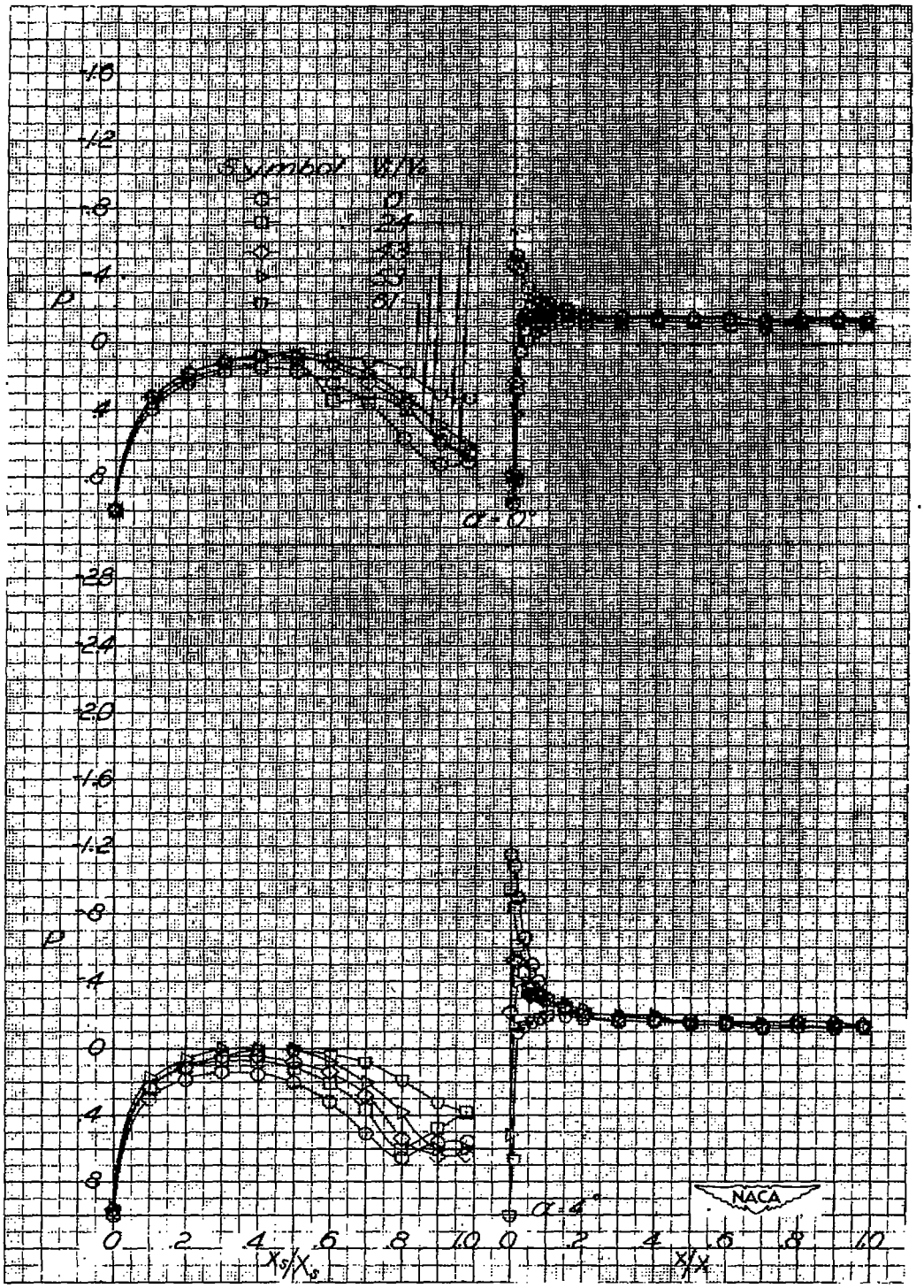


Figure 23.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-40-060 spinner.

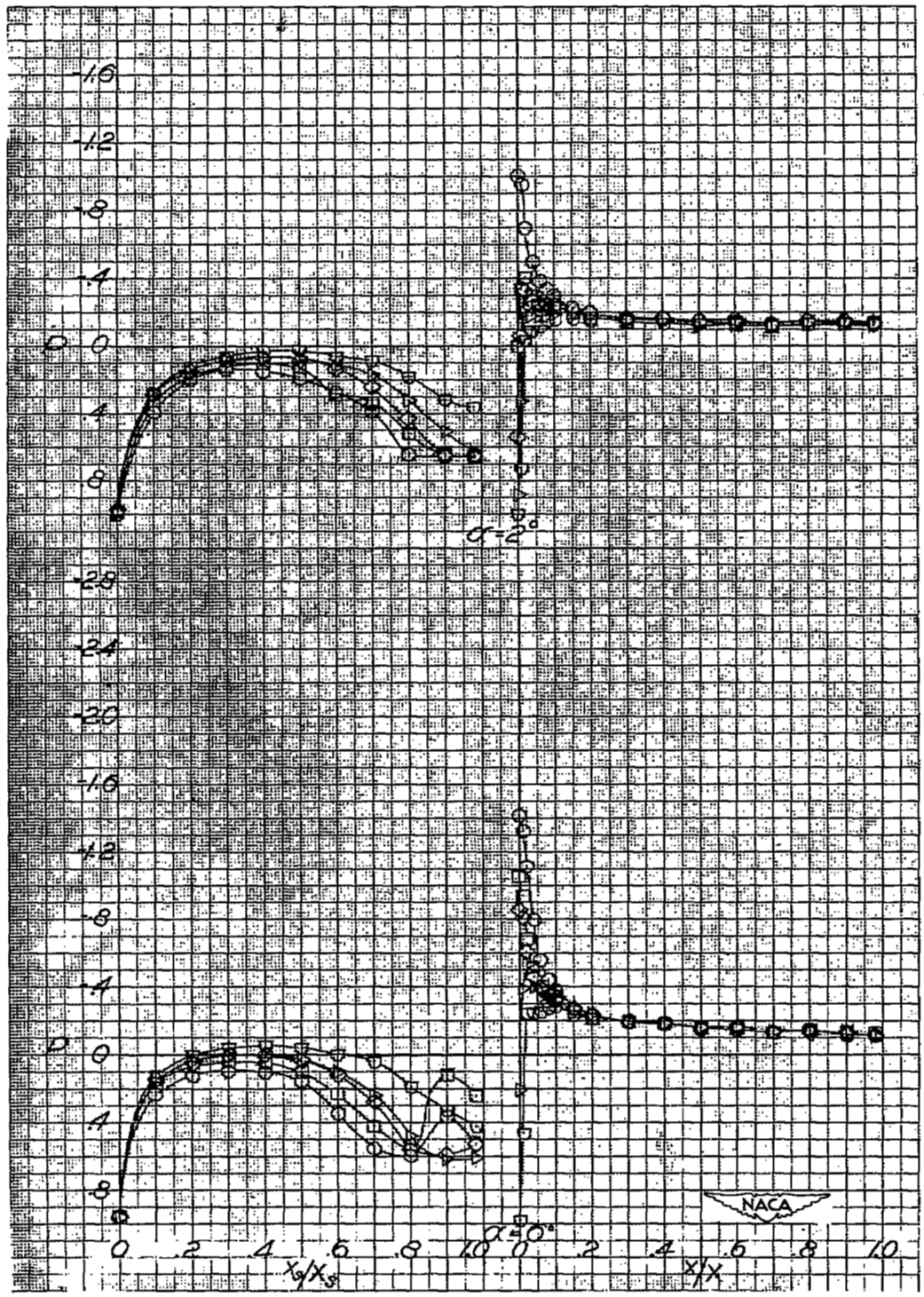


Figure 23.- Concluded.

Figure 24.- Static-pressure distributions on top of NACA 1-55-150 cowling with NACA 1-40-080 spinner.

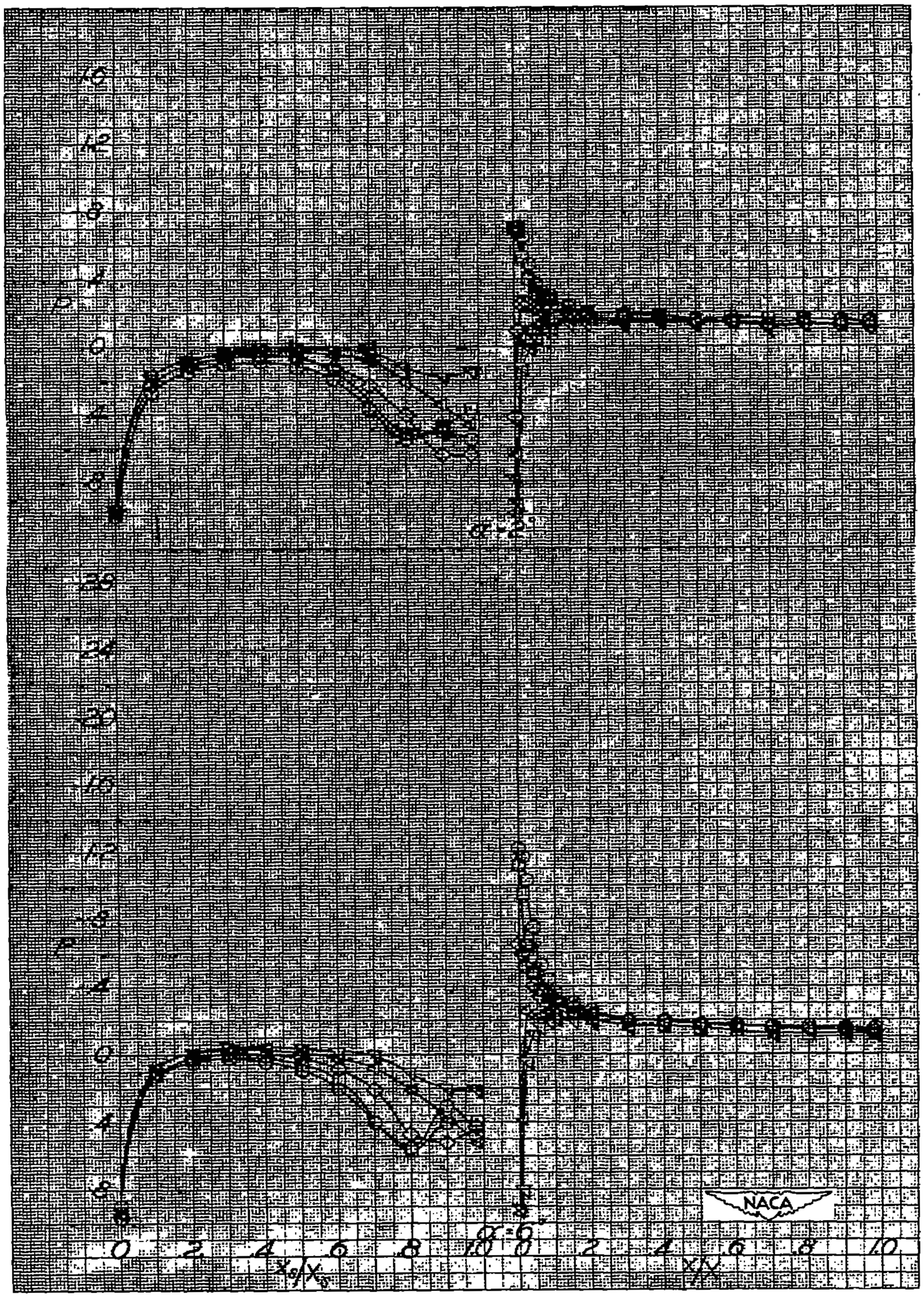


Figure 24.- Concluded.

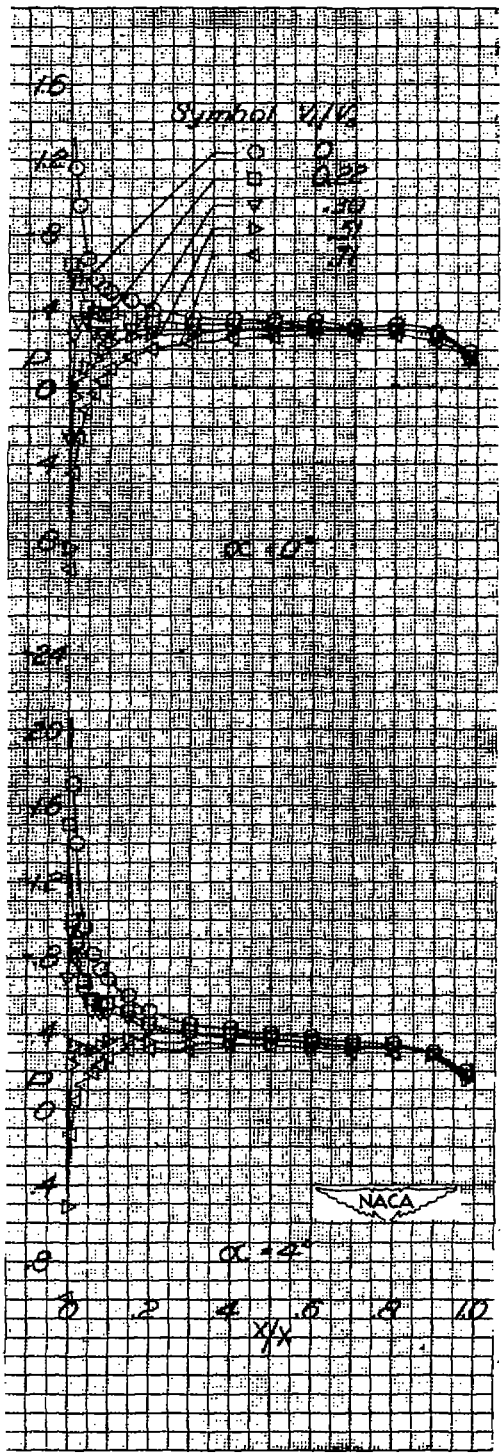


Figure 25.- Static-pressure distributions on top of NACA 1-60-075 open-nose cowling.

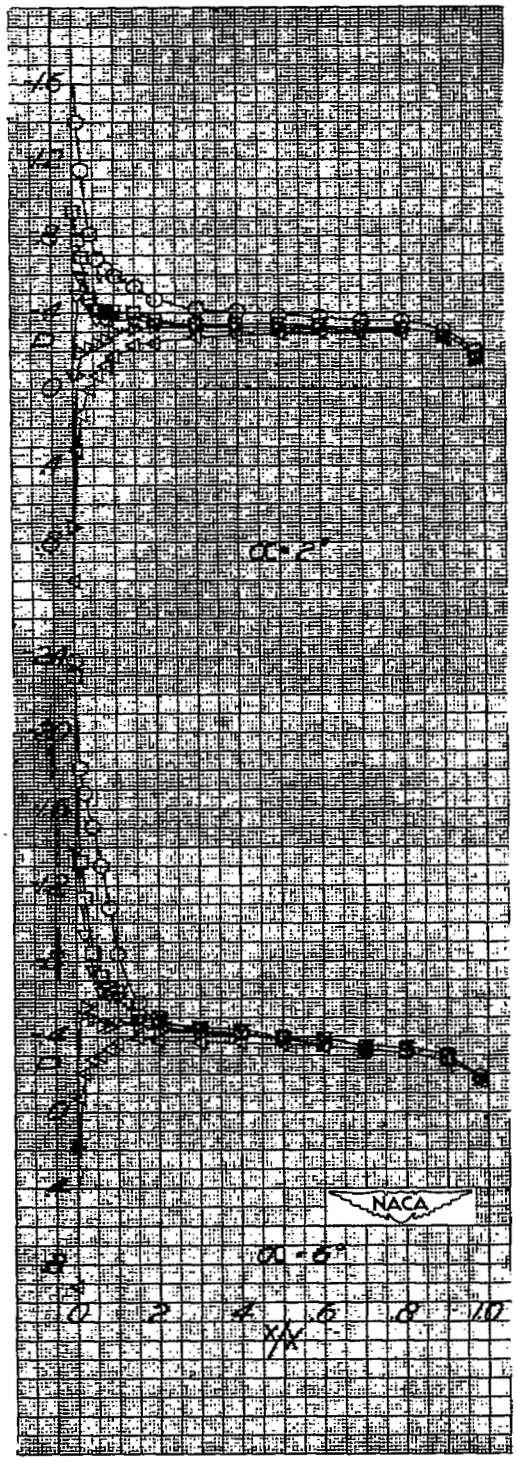


Figure 25.- Concluded.

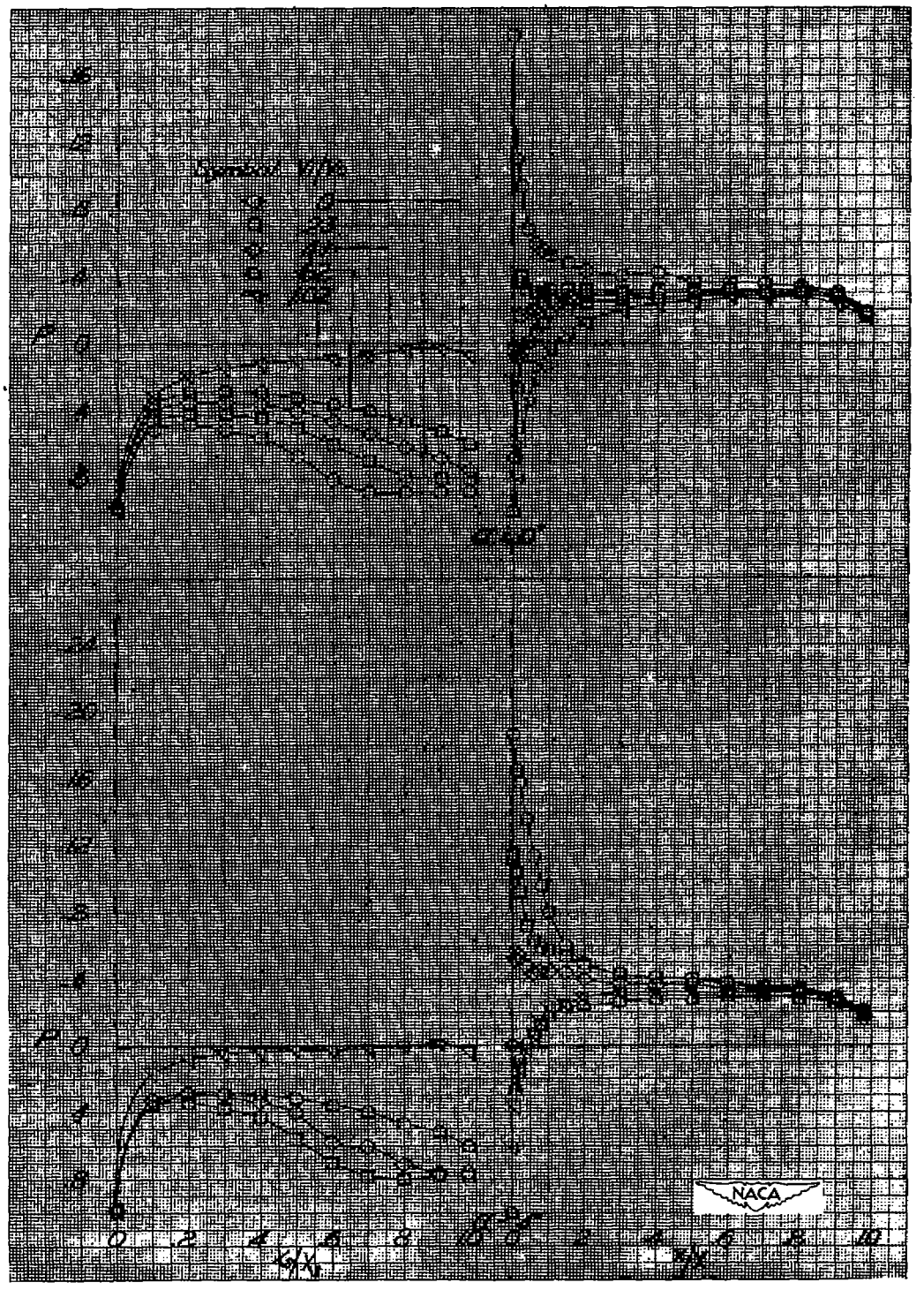


Figure 26.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-20-040 spinner.

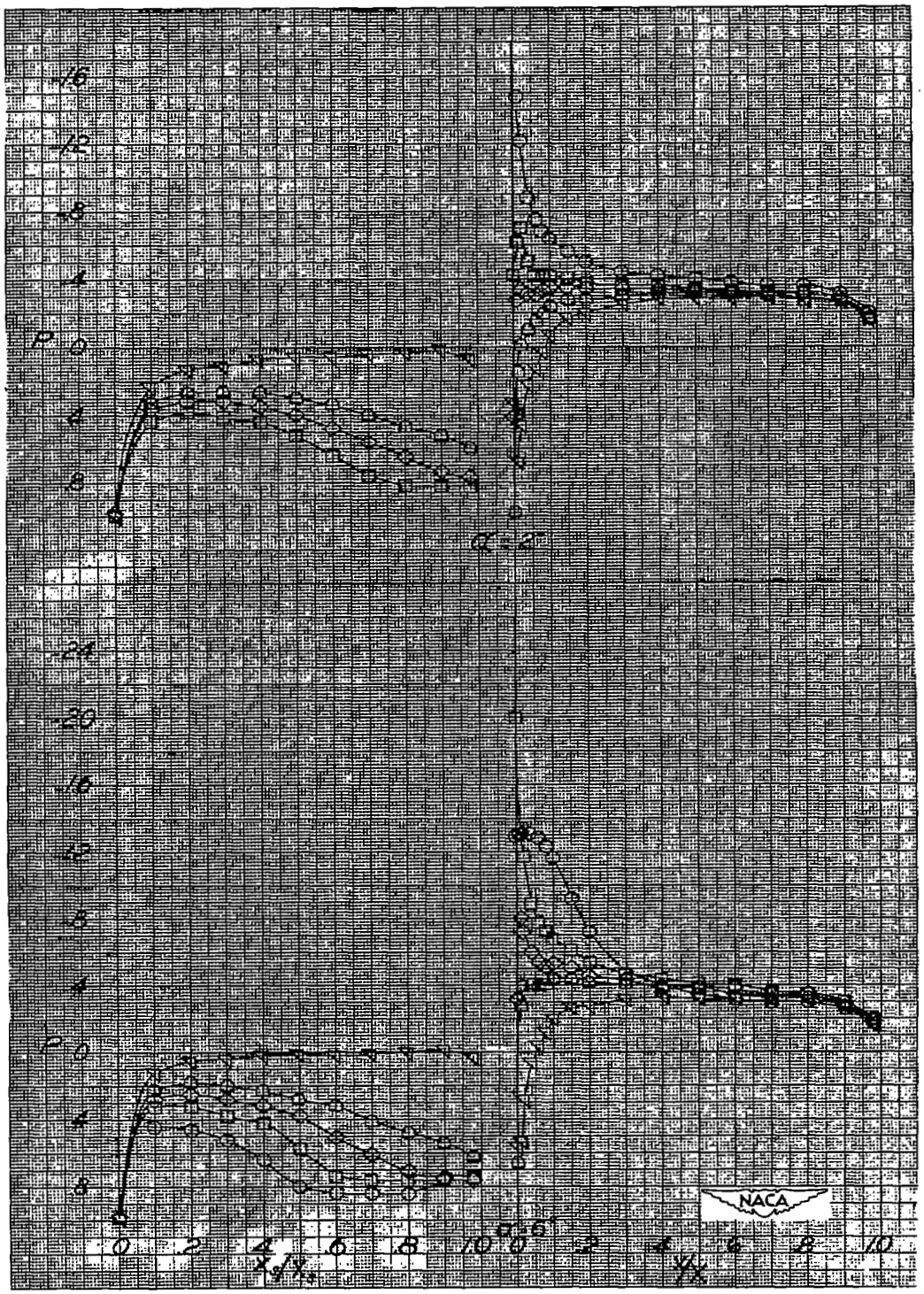


Figure 26.- Concluded.

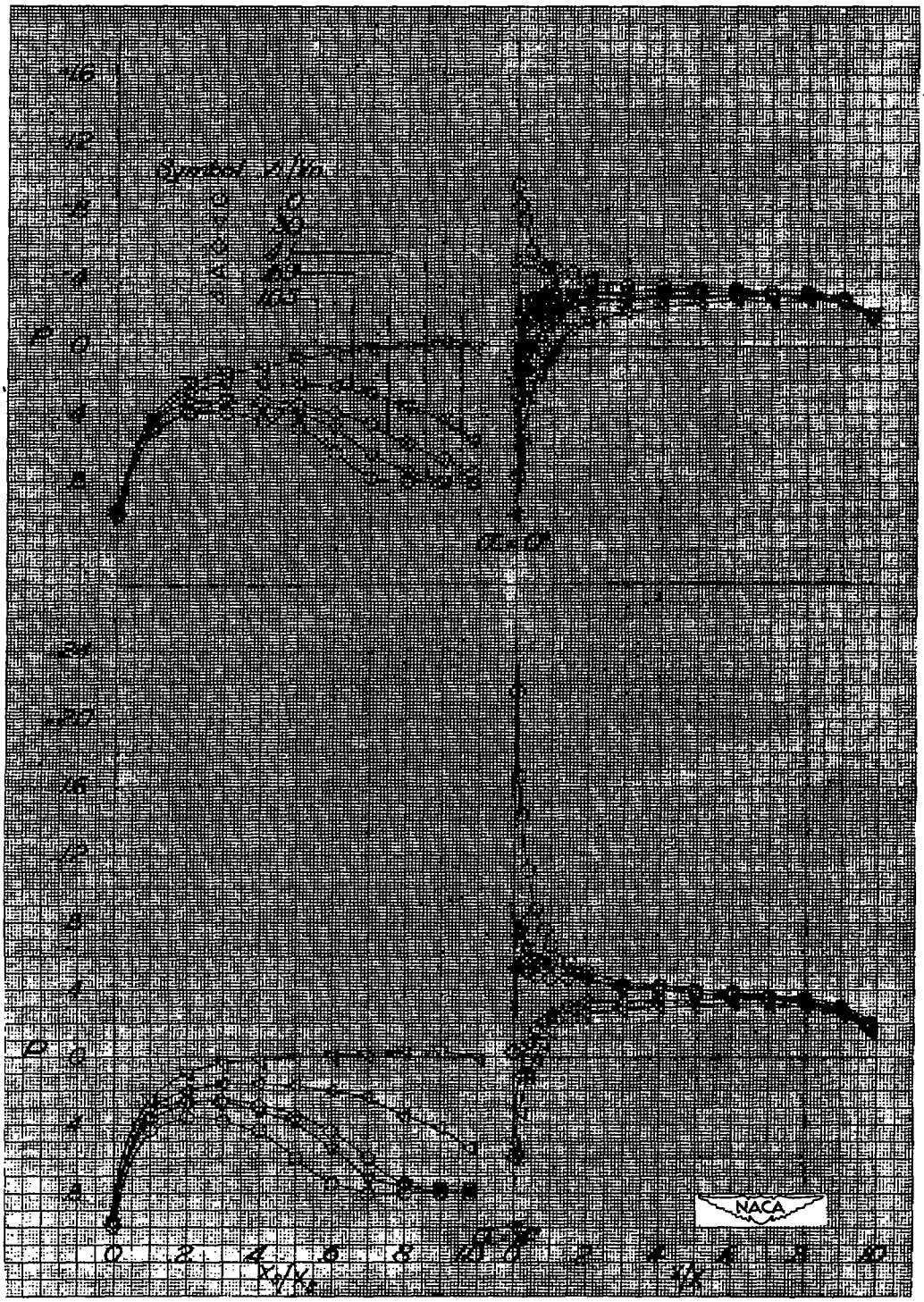


Figure 27.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-30-040 spinner.

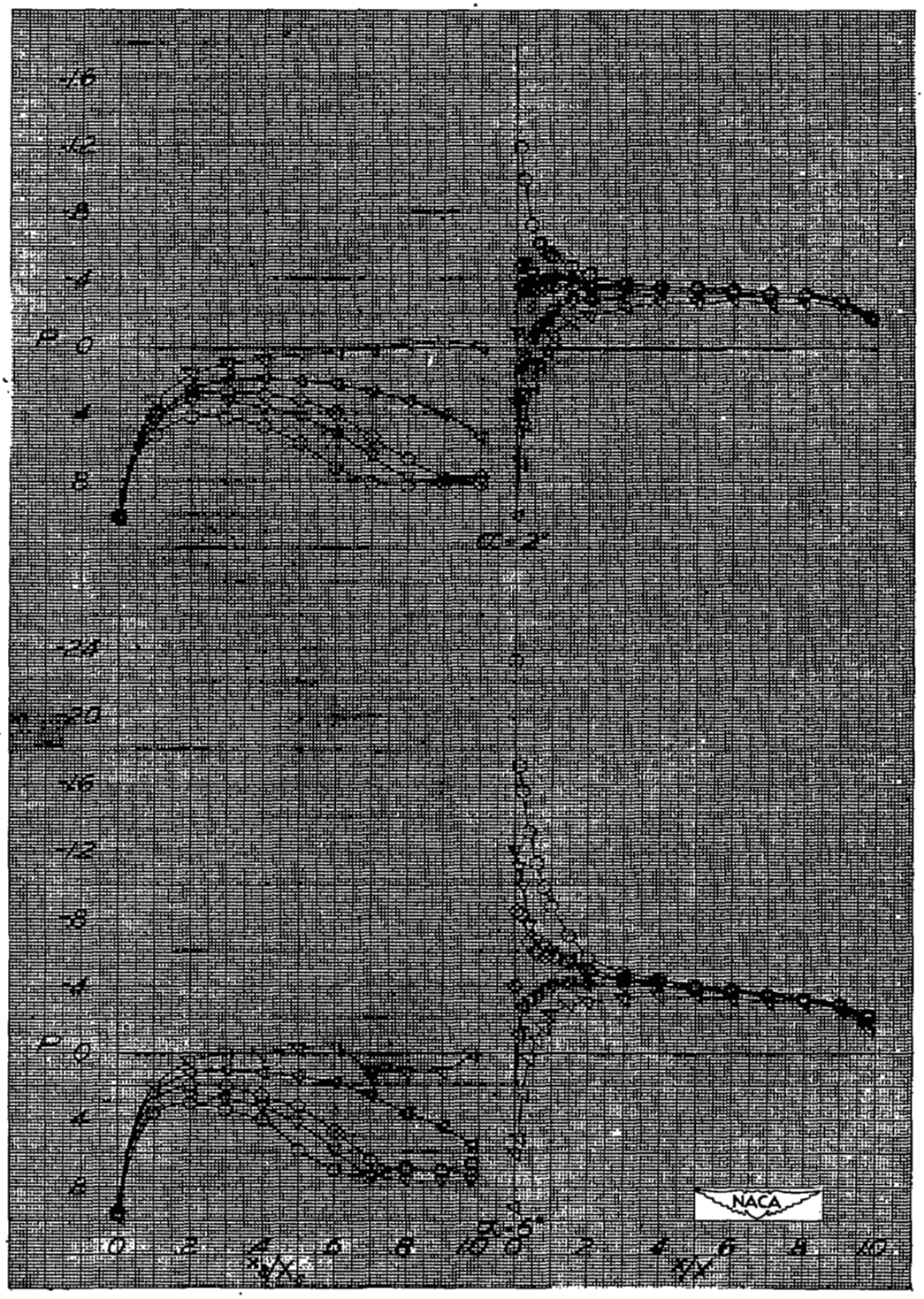


Figure 27.- Concluded.

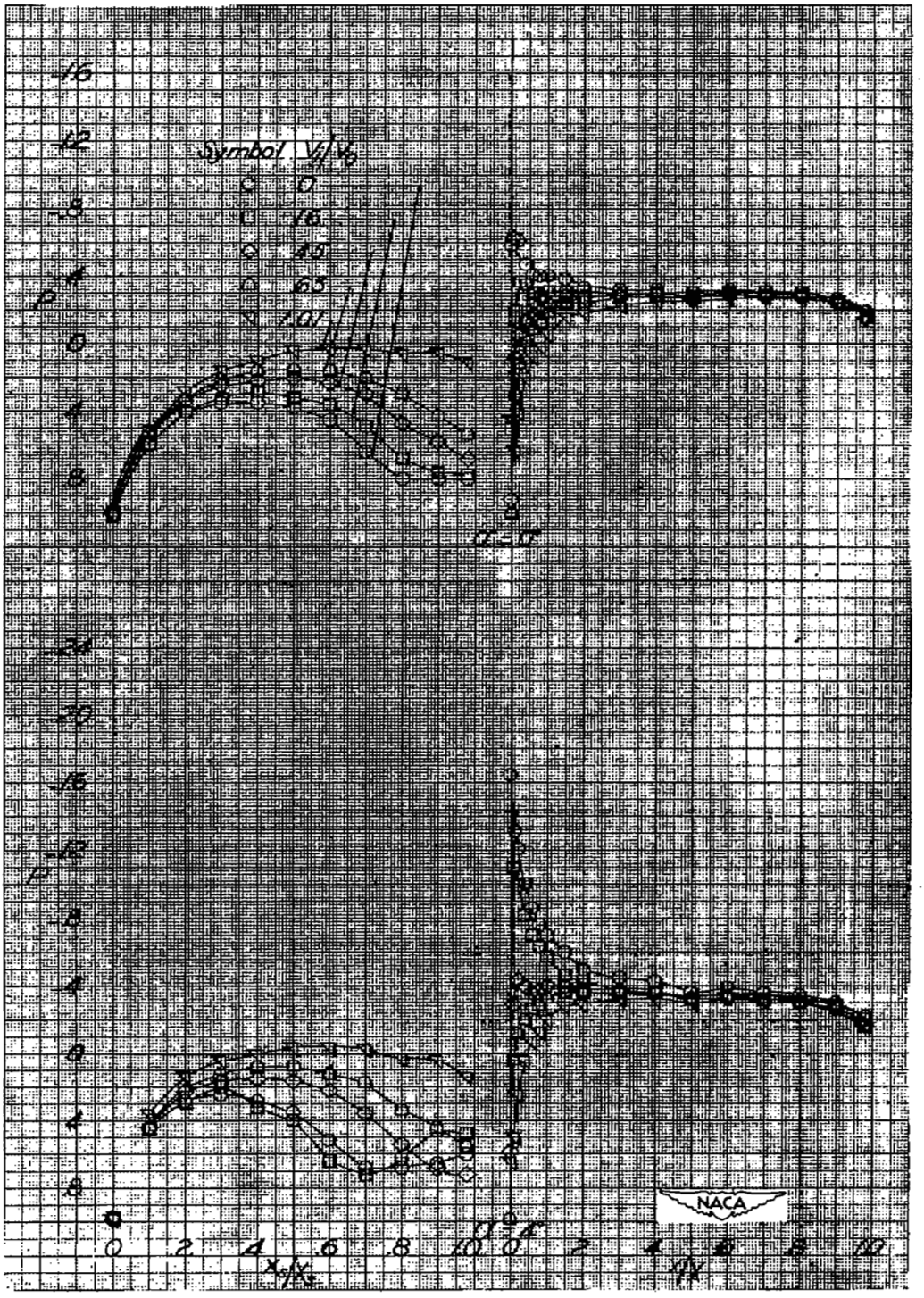


Figure 28.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-40-040 spinner.

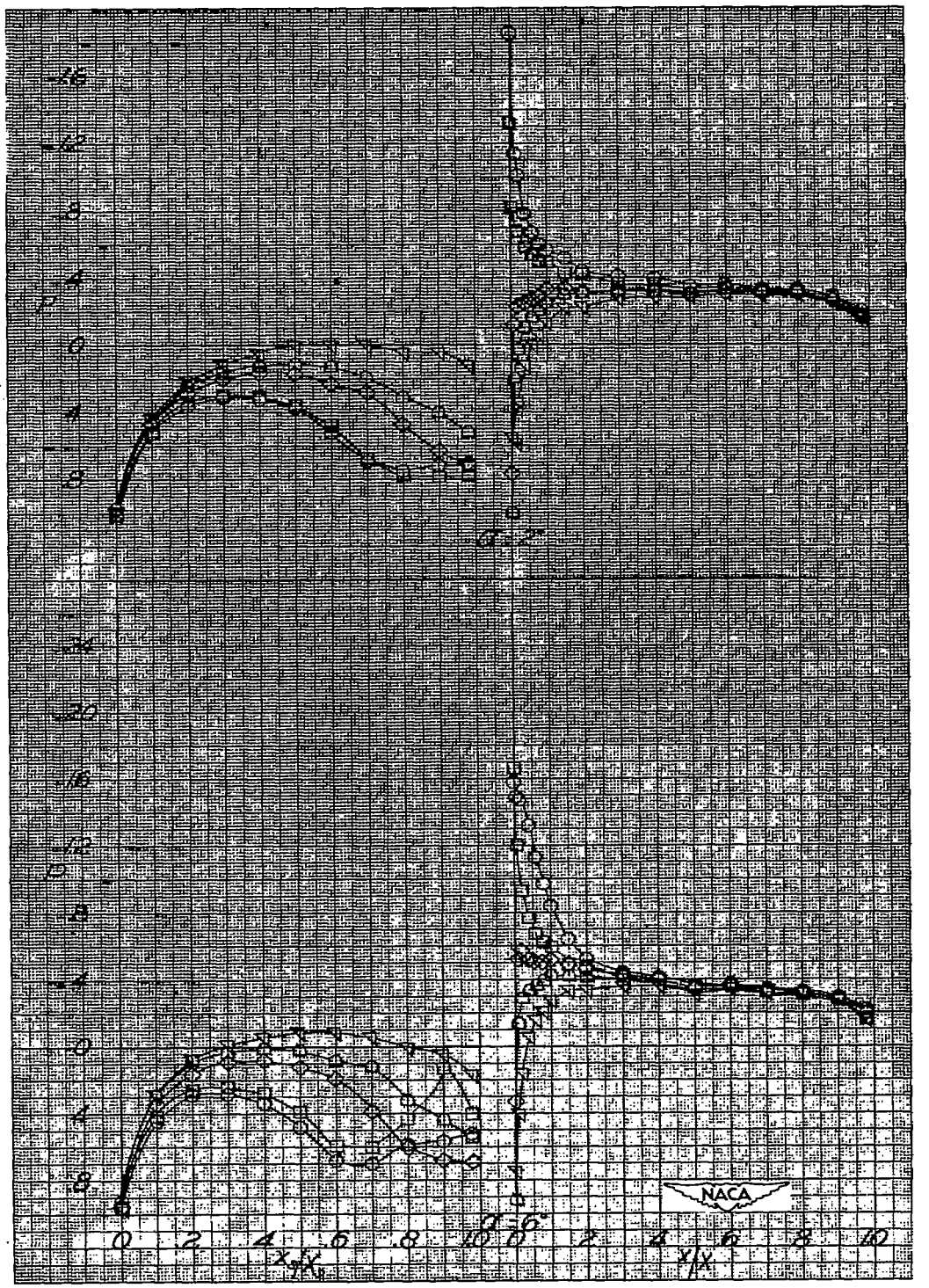


Figure 28.- Concluded.

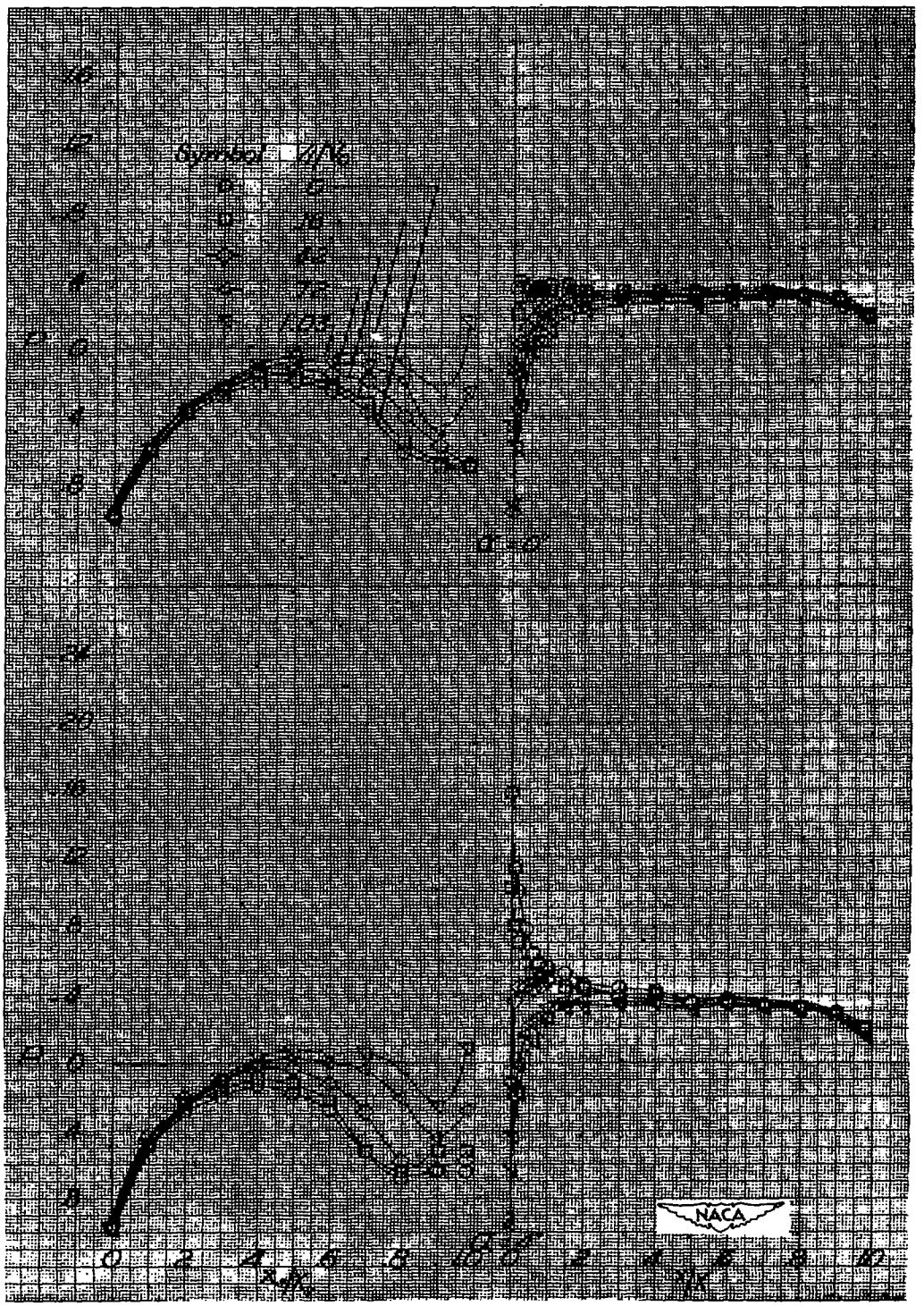


Figure 29.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-50-040 spinner.

Figure 29.- Concluded.

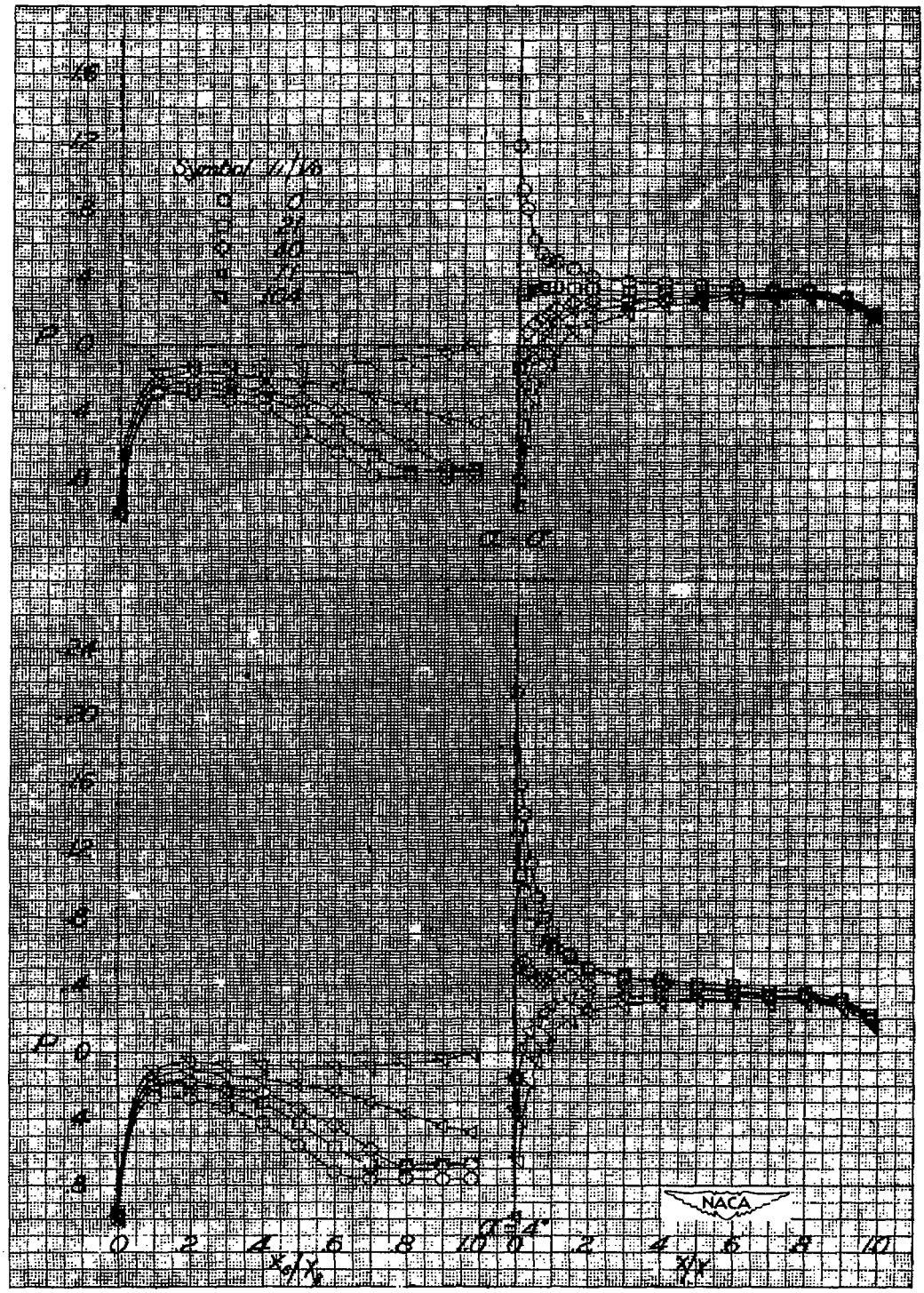


Figure 30.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-20-060 spinner.

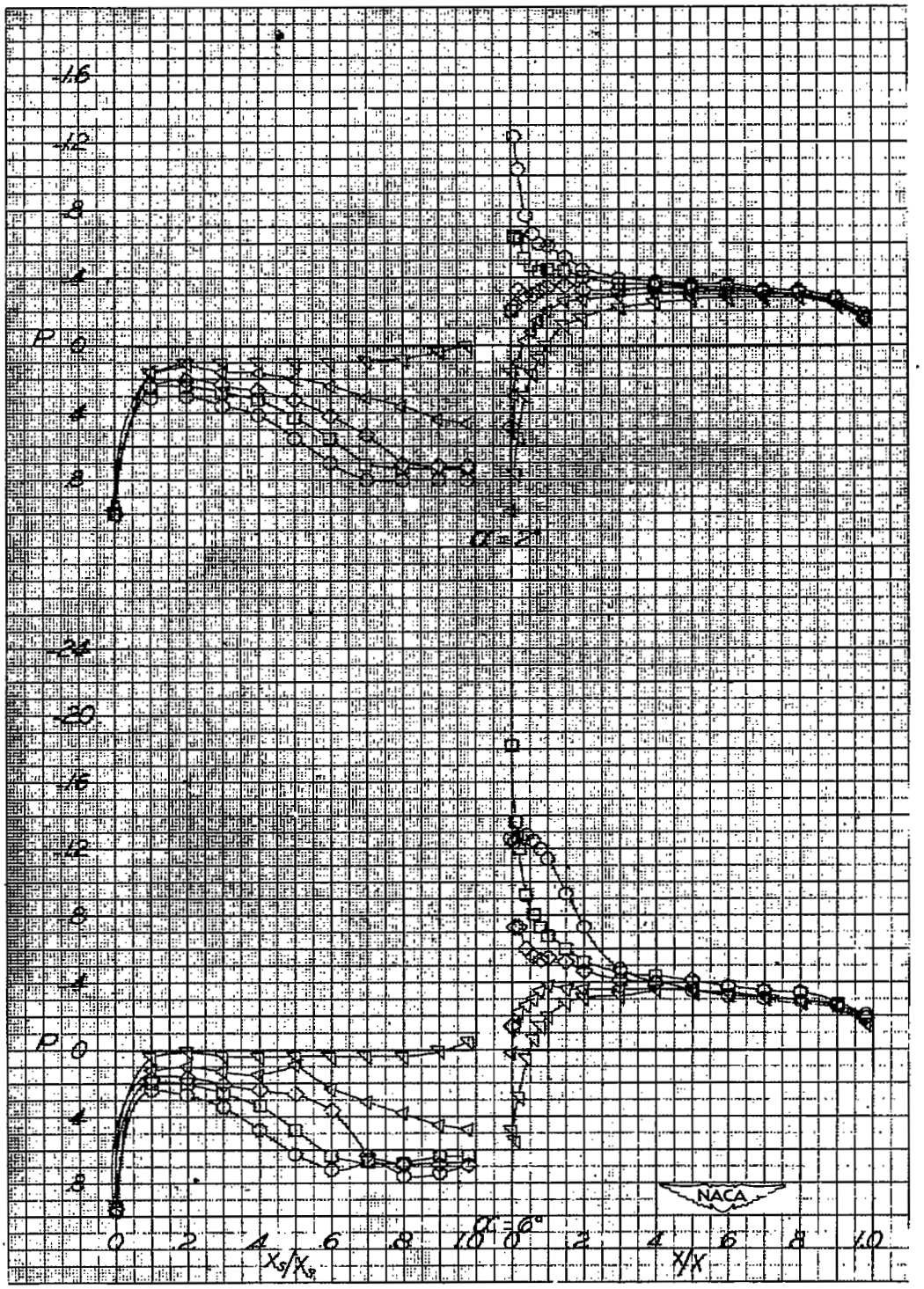


Figure 30.- Concluded.

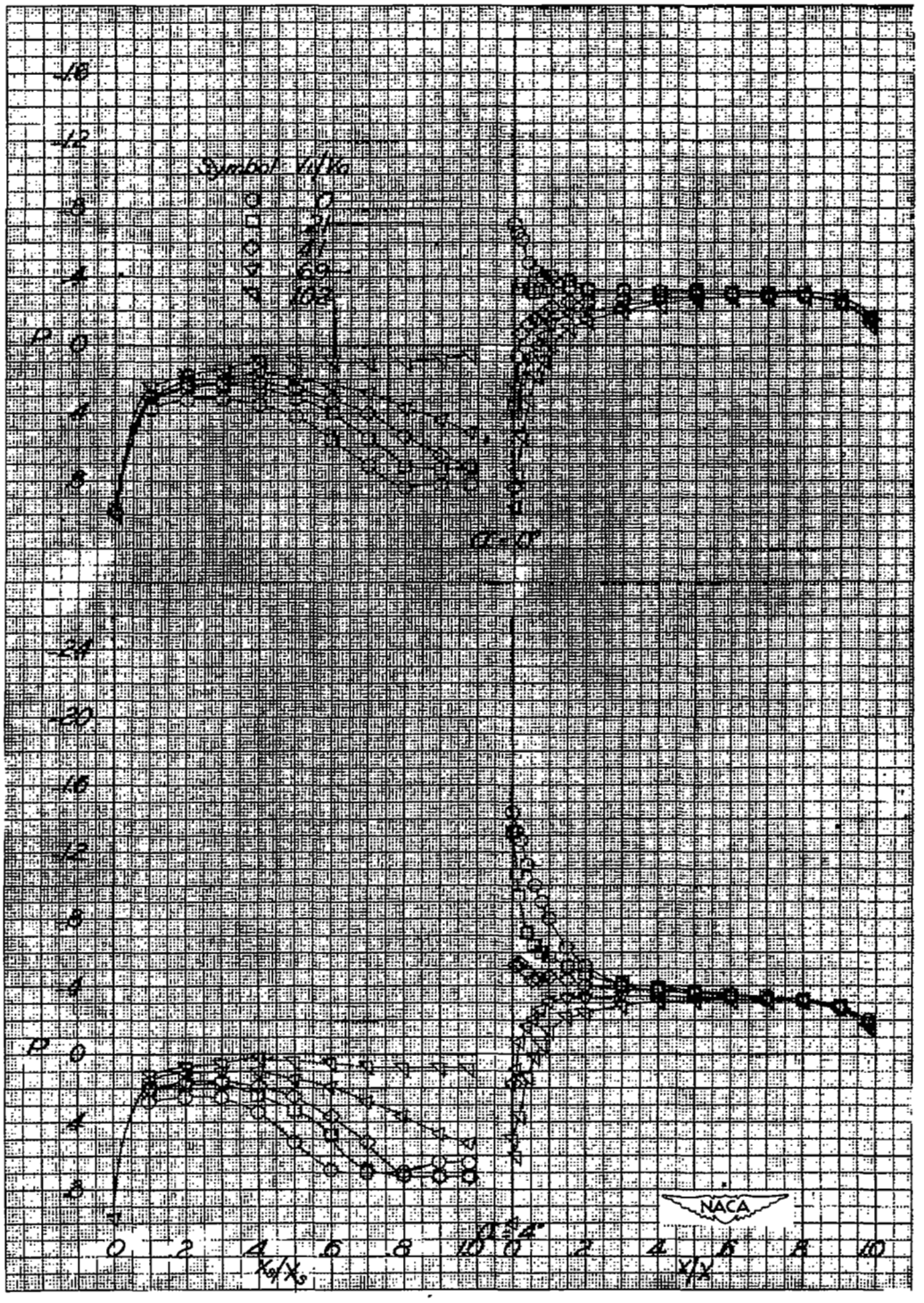


Figure 31.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-30-060 spinner.

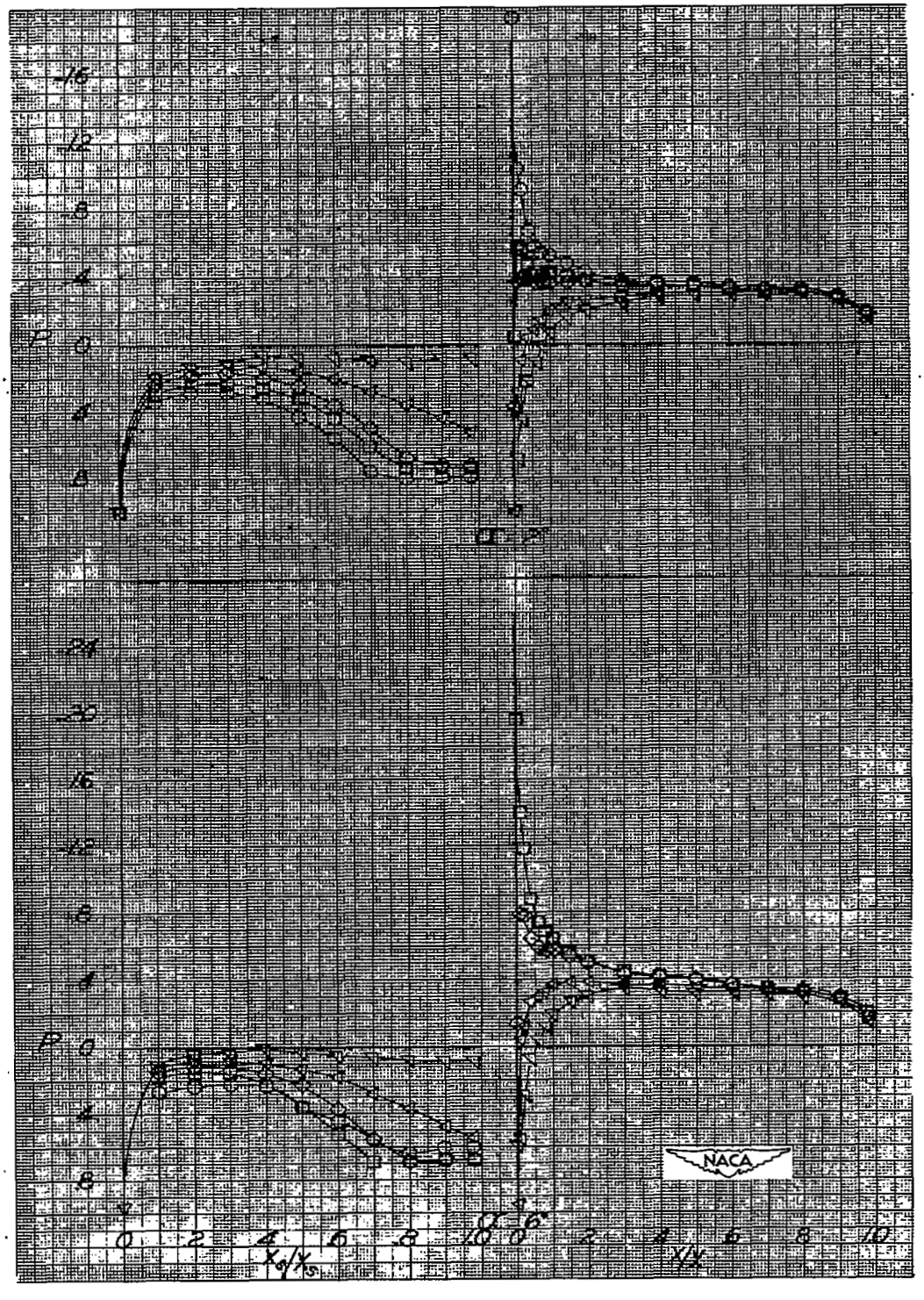


Figure 31.- Concluded.

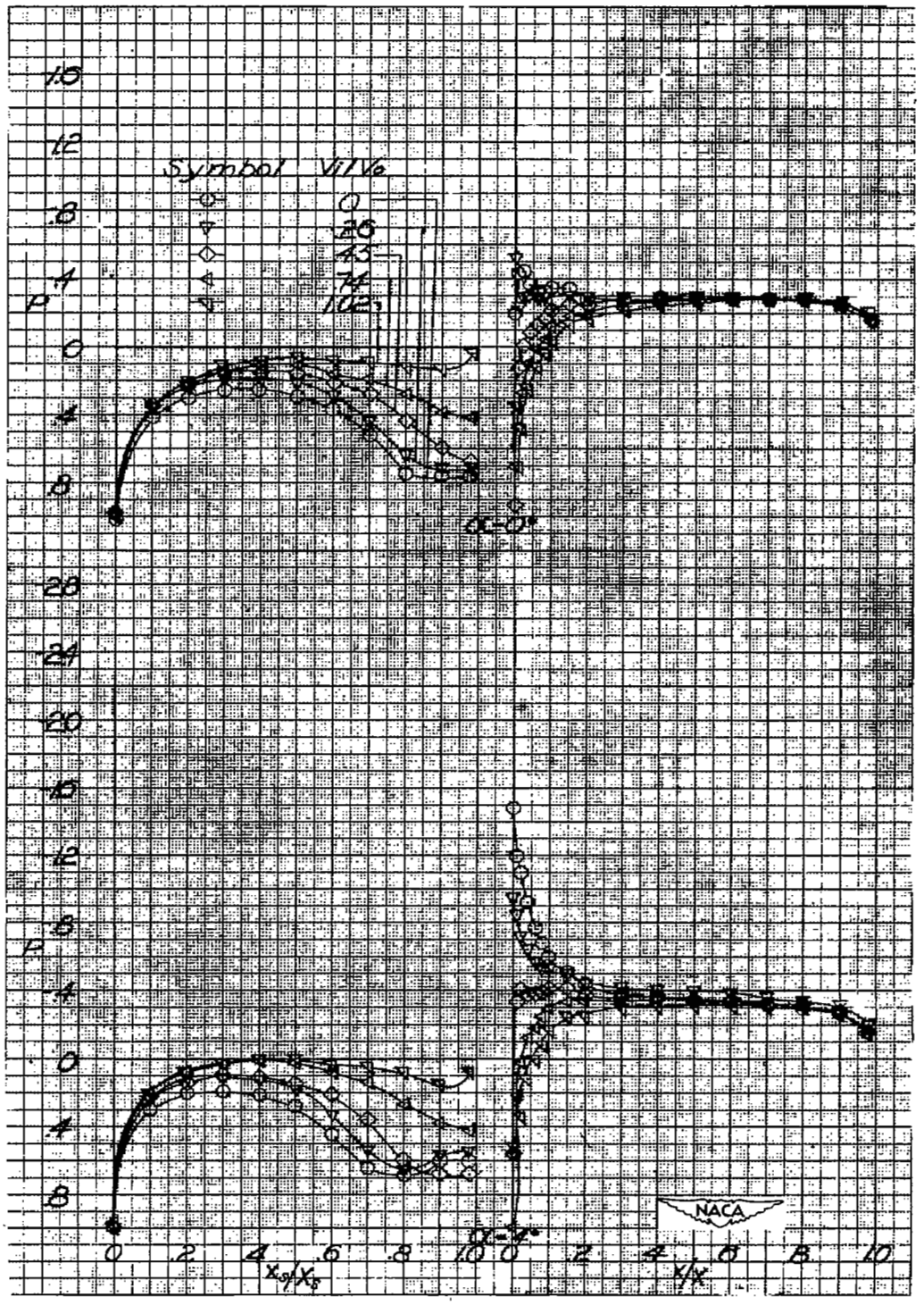


Figure 32.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-40-060 spinner.

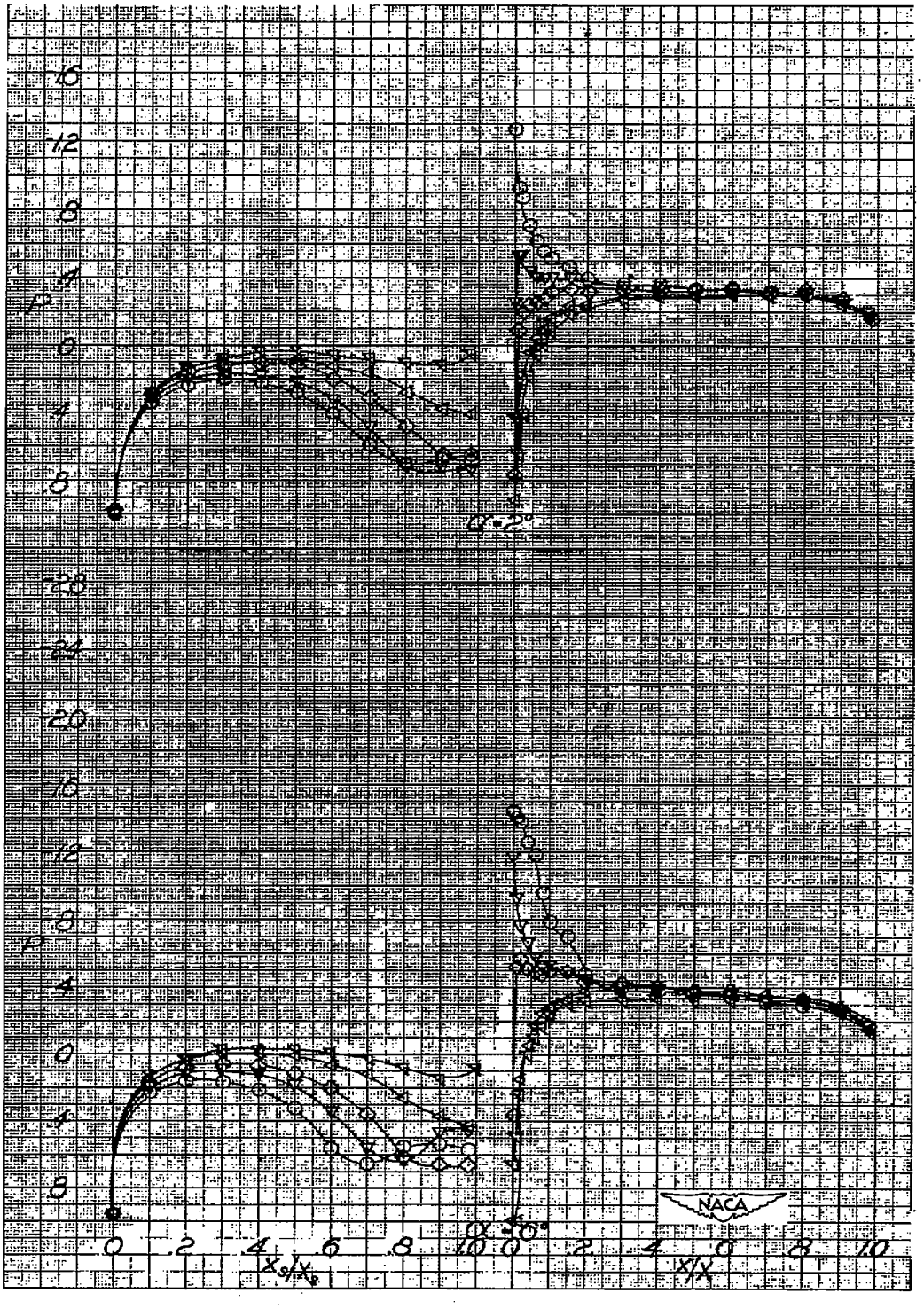


Figure 32.- Concluded.

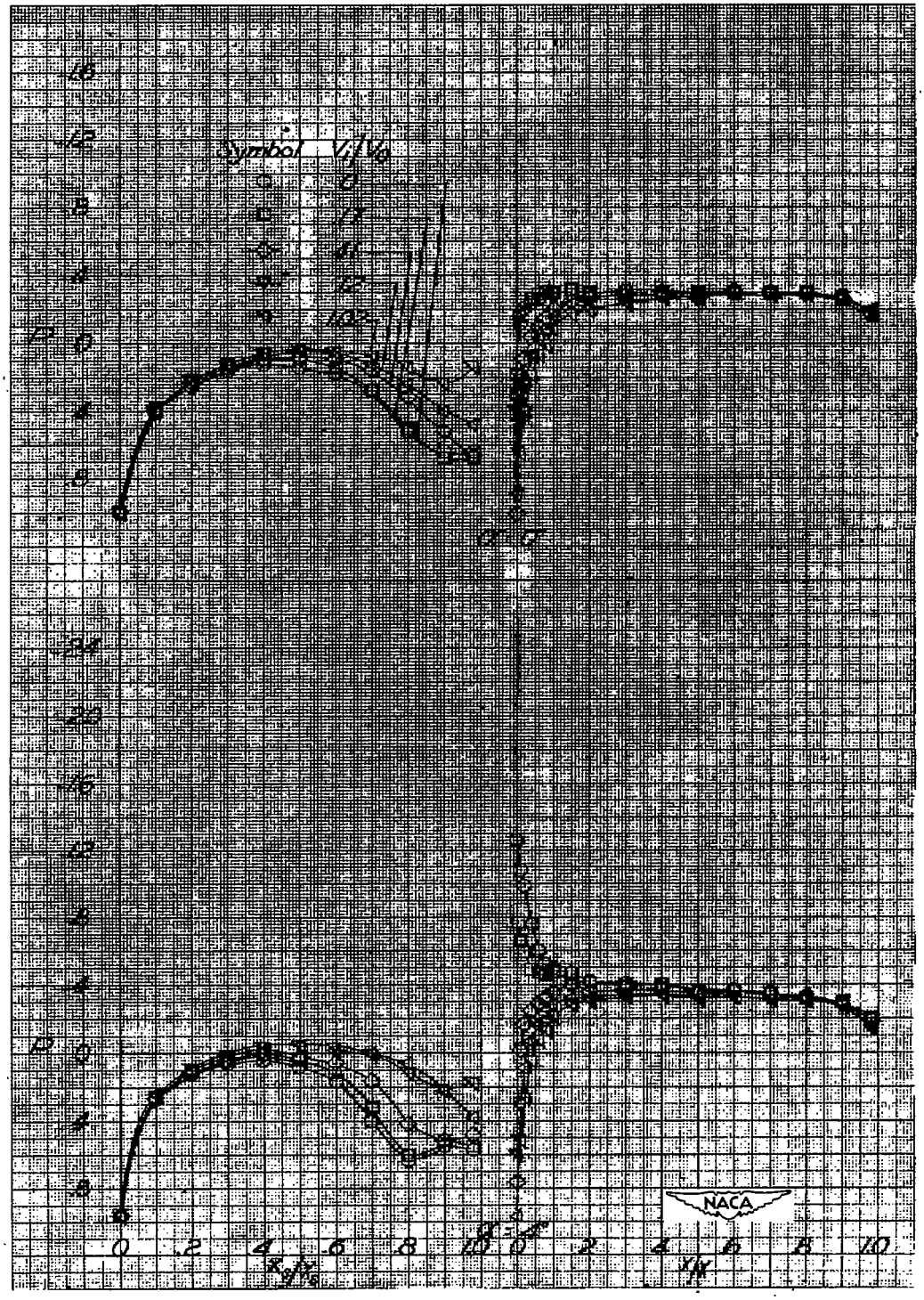


Figure 33.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-50-060 spinner.

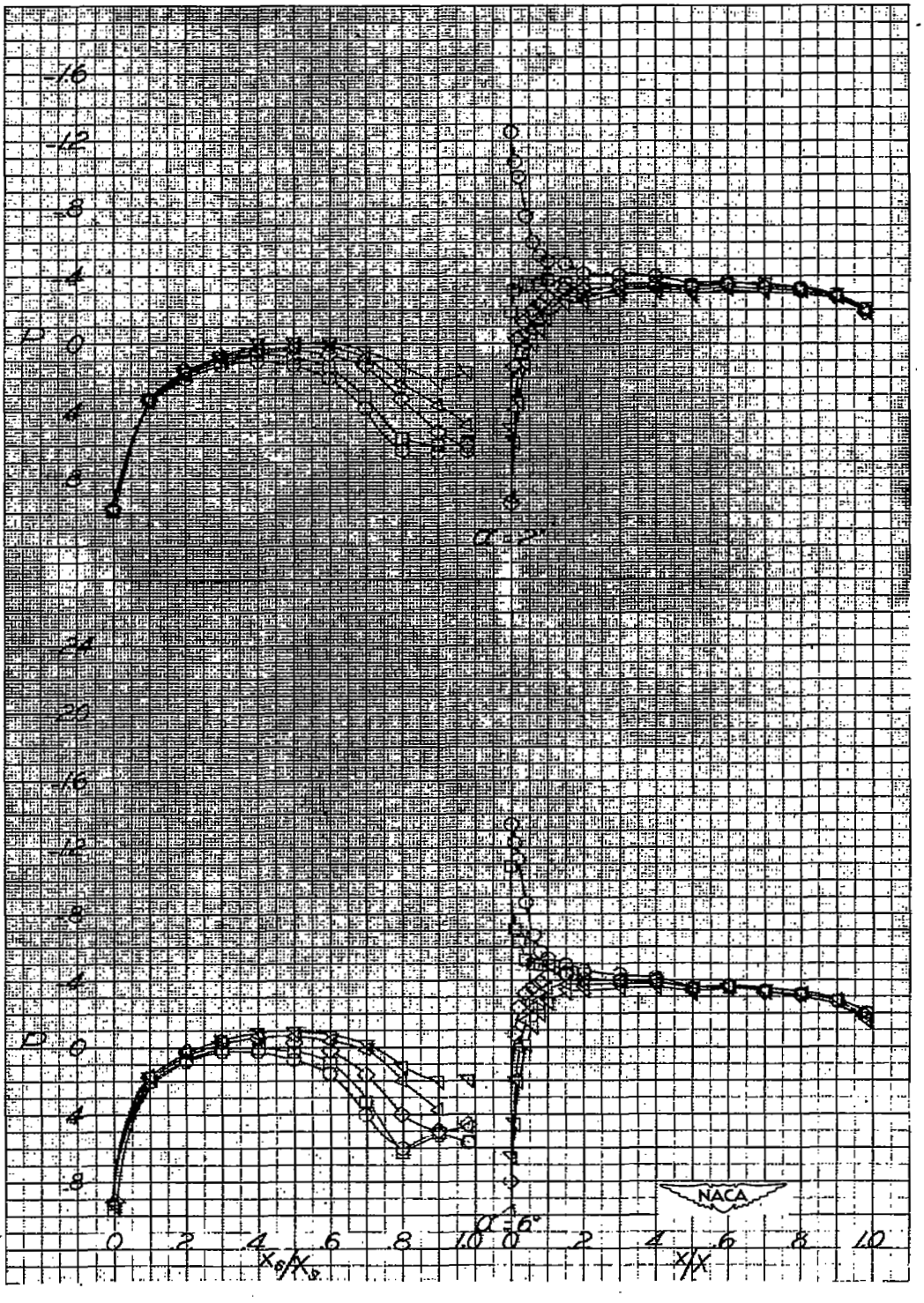


Figure 33.- Concluded.

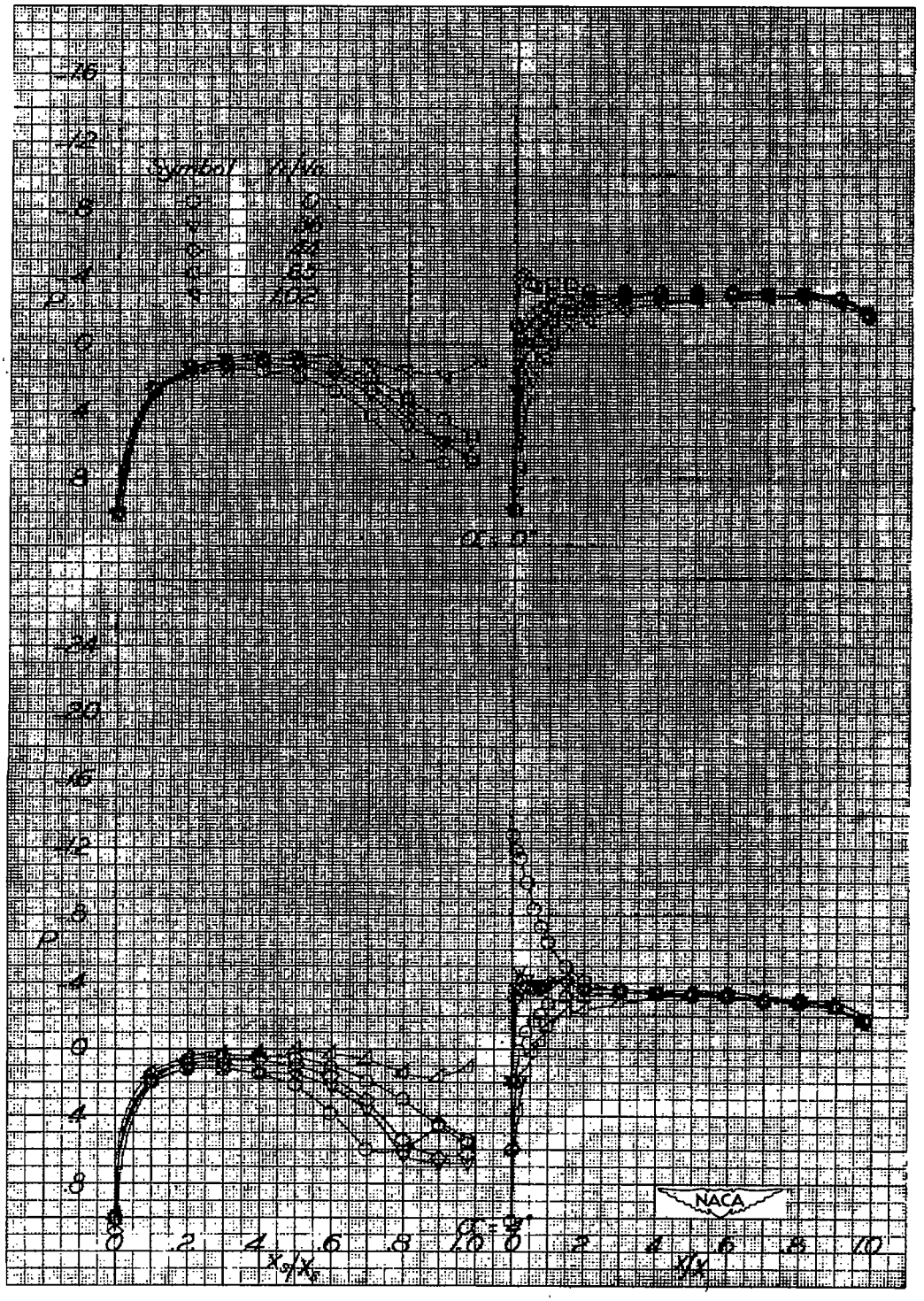


Figure 34.- Static-pressure distributions on top of NACA 1-60-075 cowling with NACA 1-40-080 spinner.

Figure 34.- Concluded.

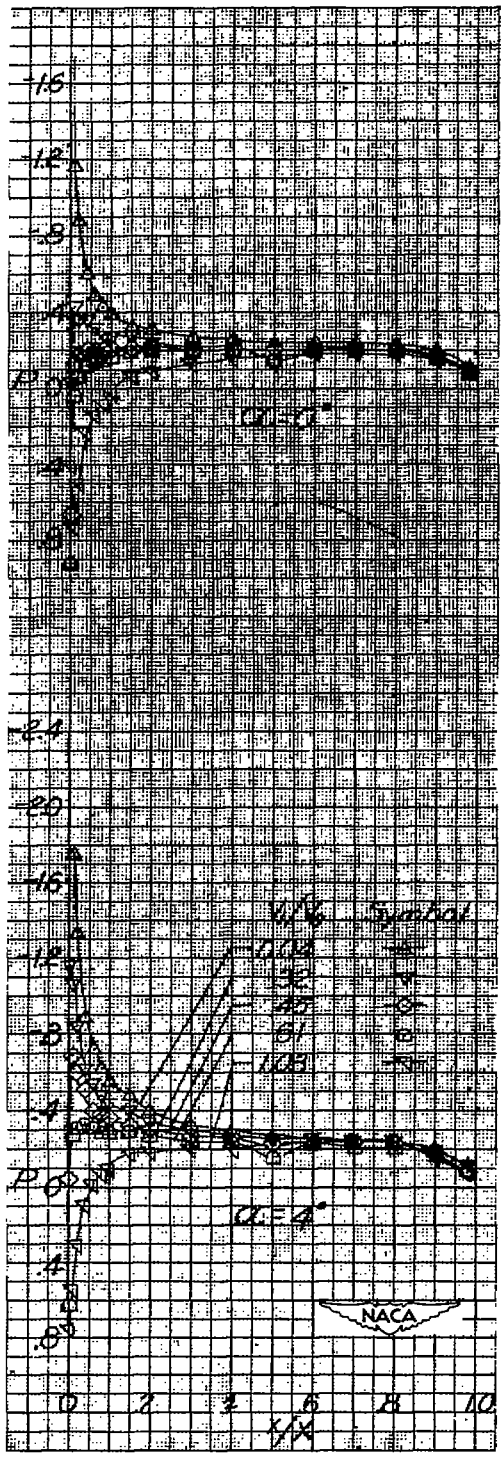


Figure 35.- Static-pressure distributions on top of NACA 1-60-100 open-nose cowling.

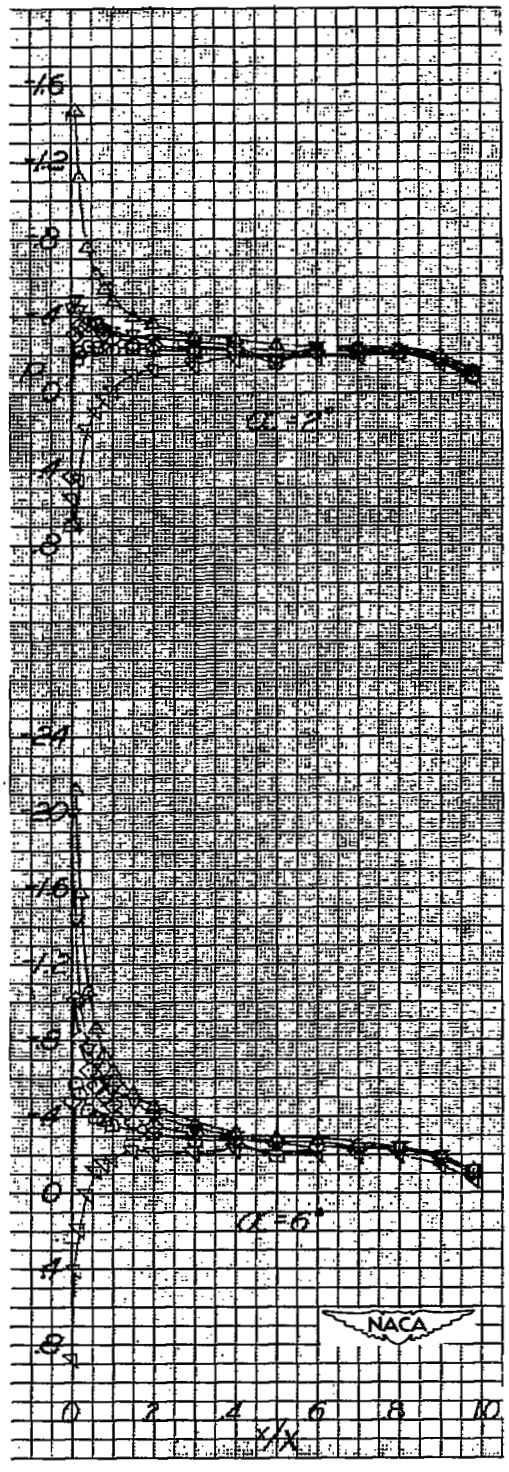


Figure 35.- Concluded.

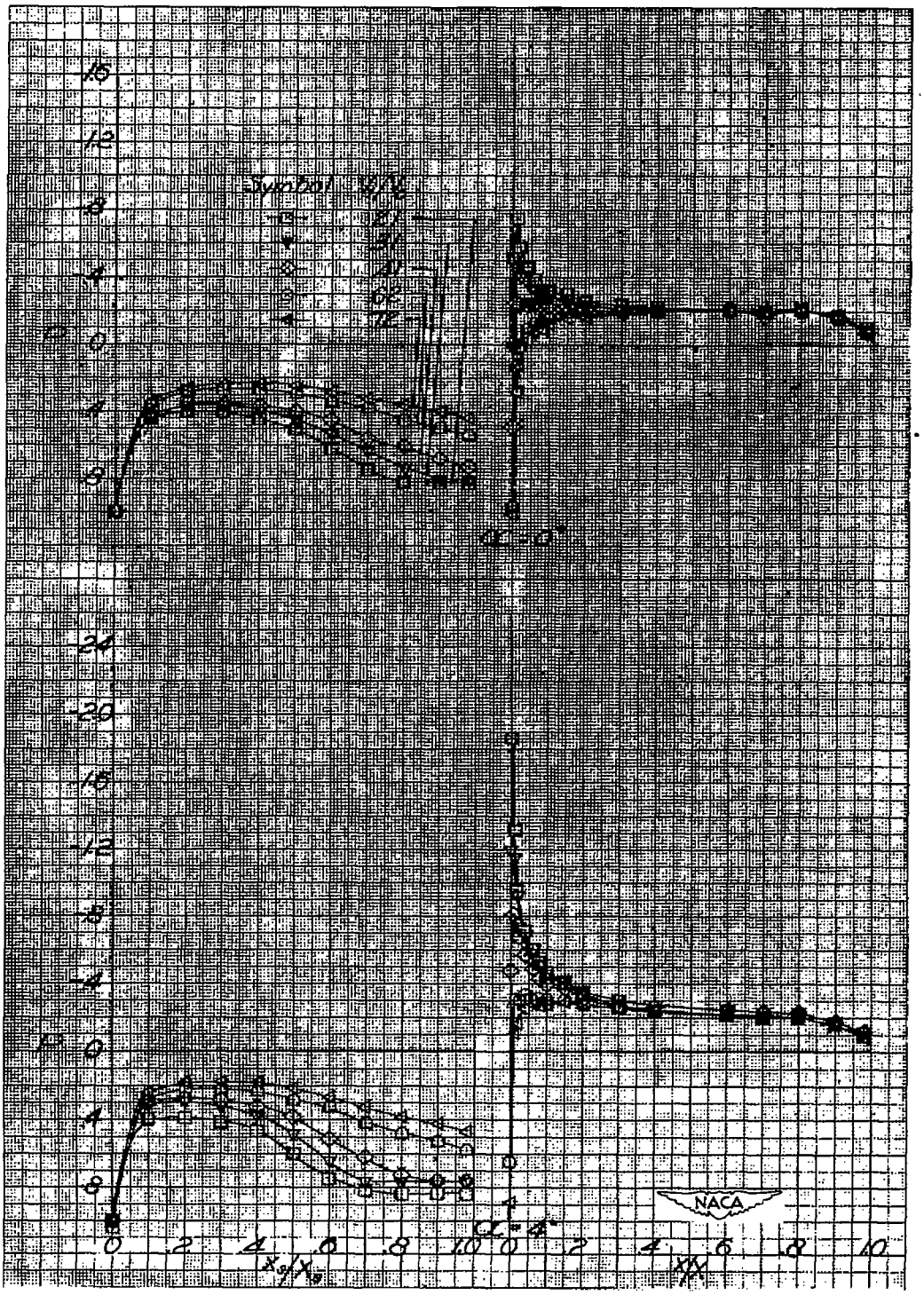


Figure 36.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-20-040 spinner.

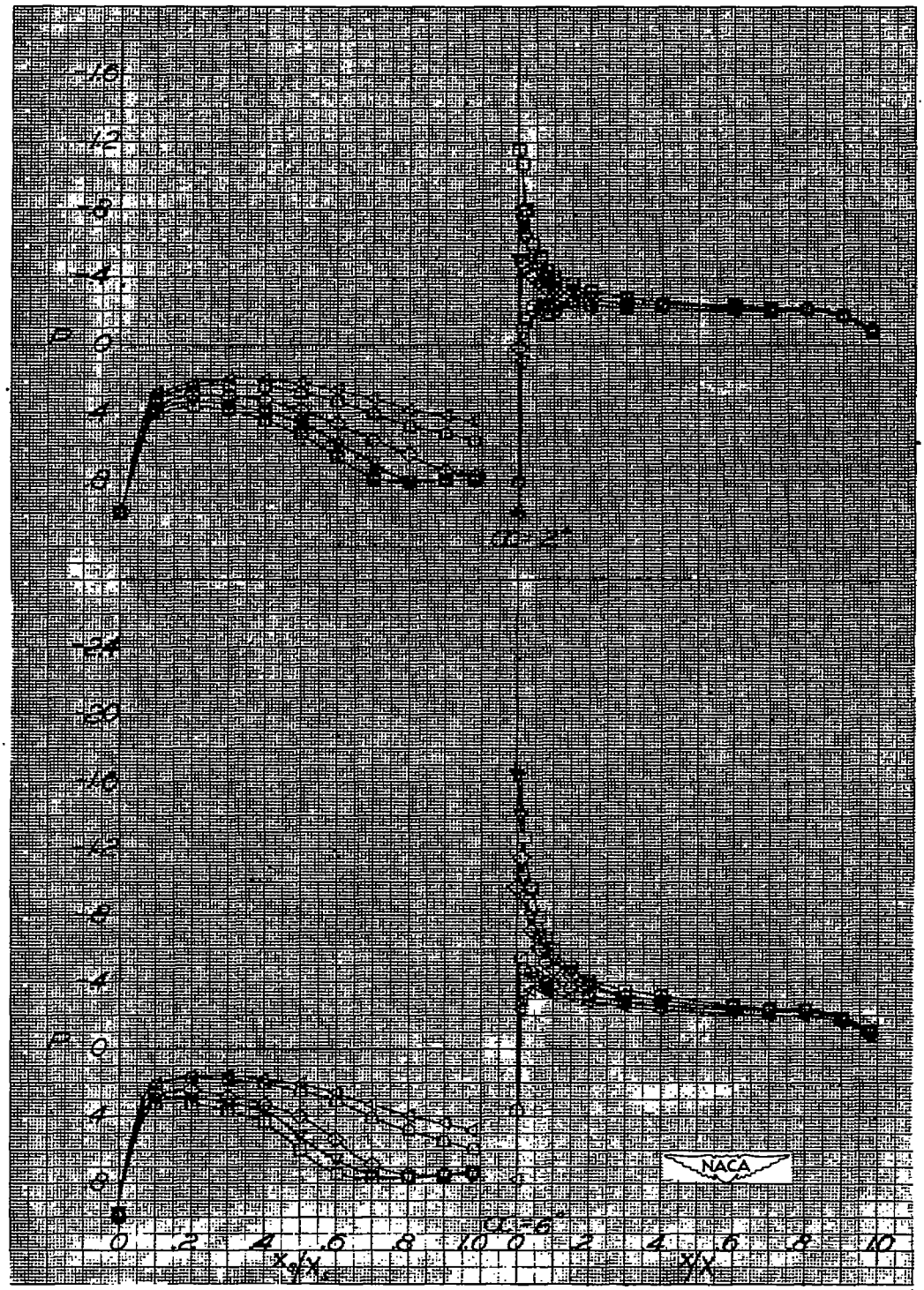


Figure 36.- Concluded.

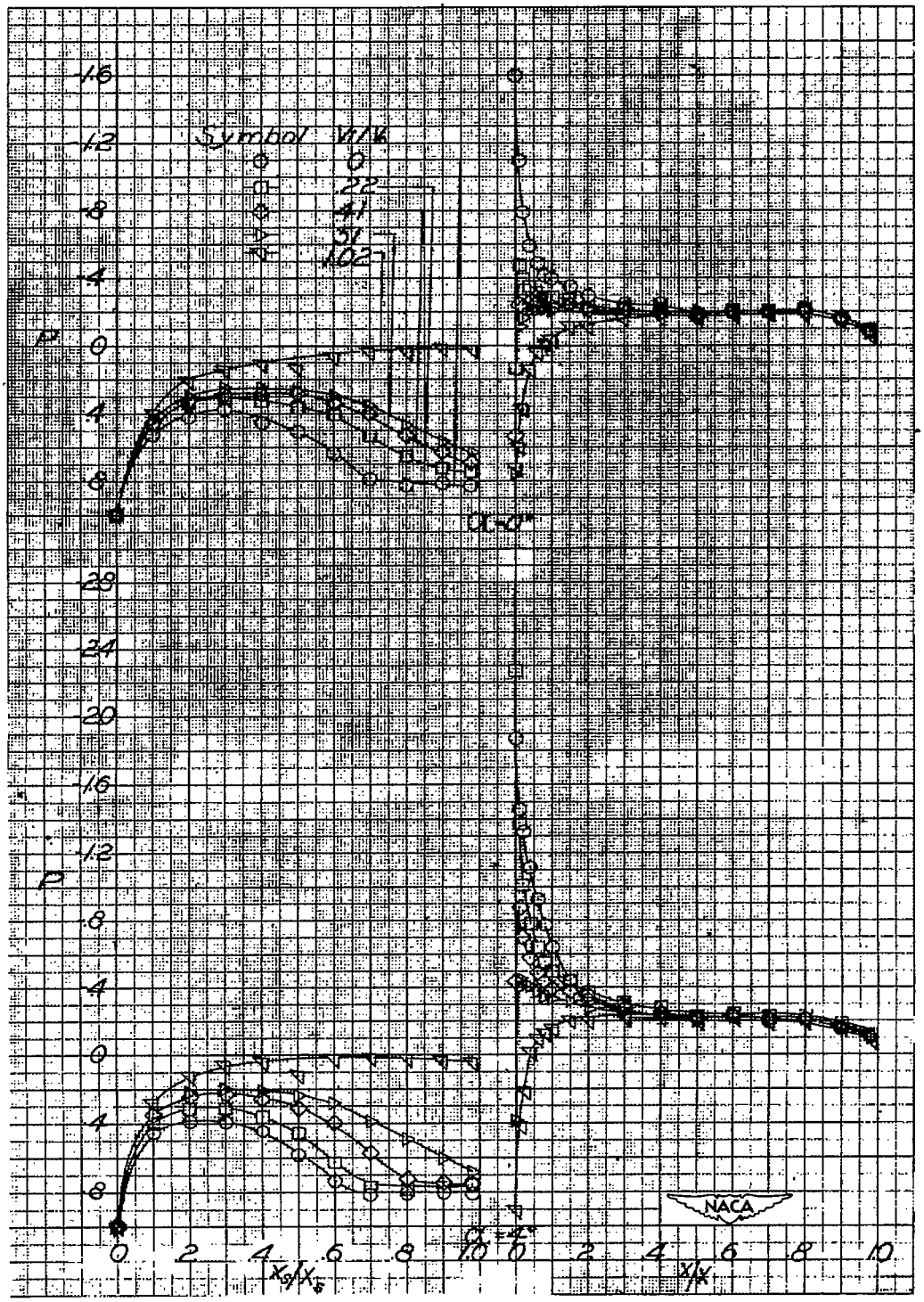


Figure 37.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-30-040 spinner.

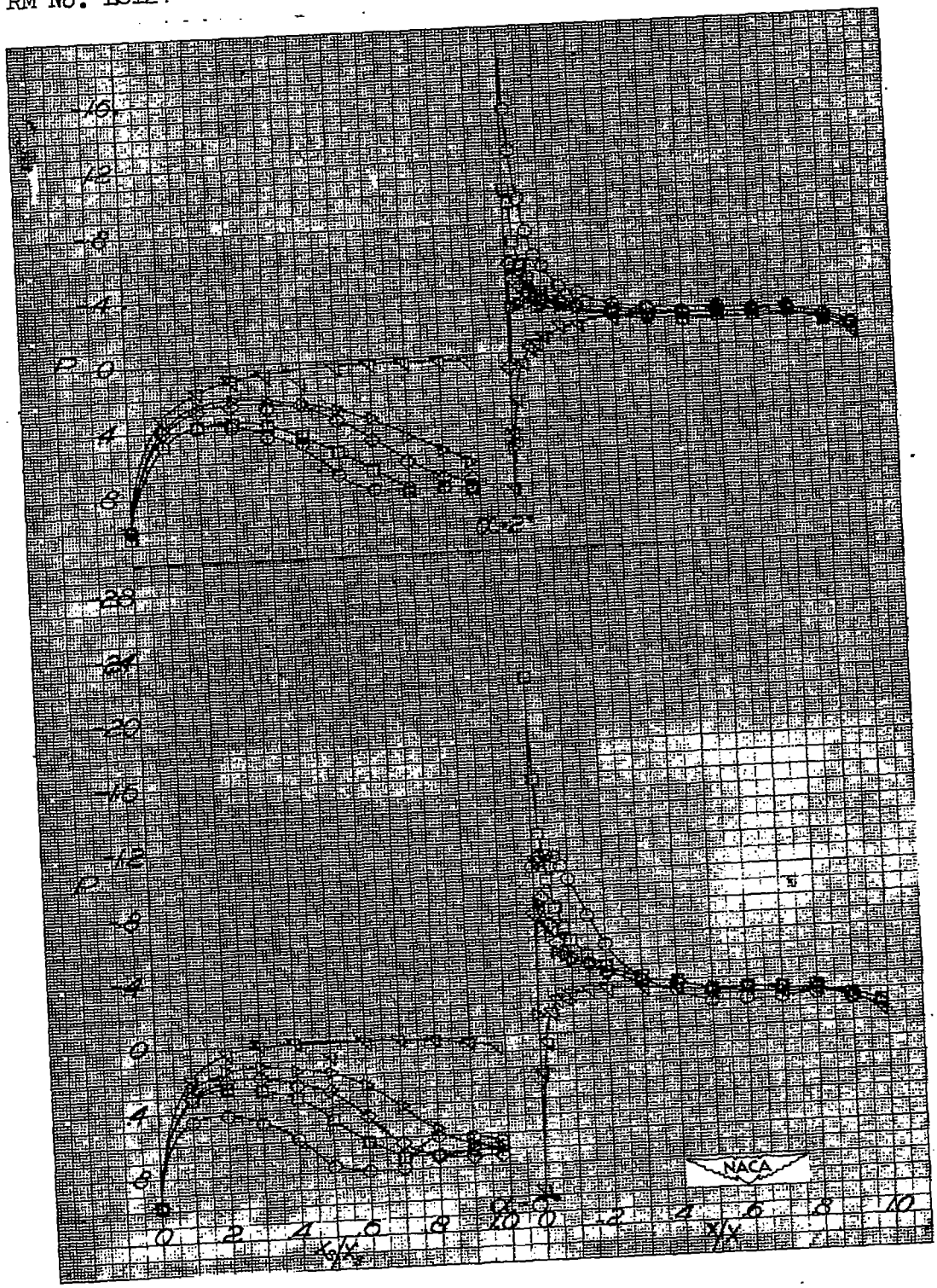


Figure 37.- Concluded.

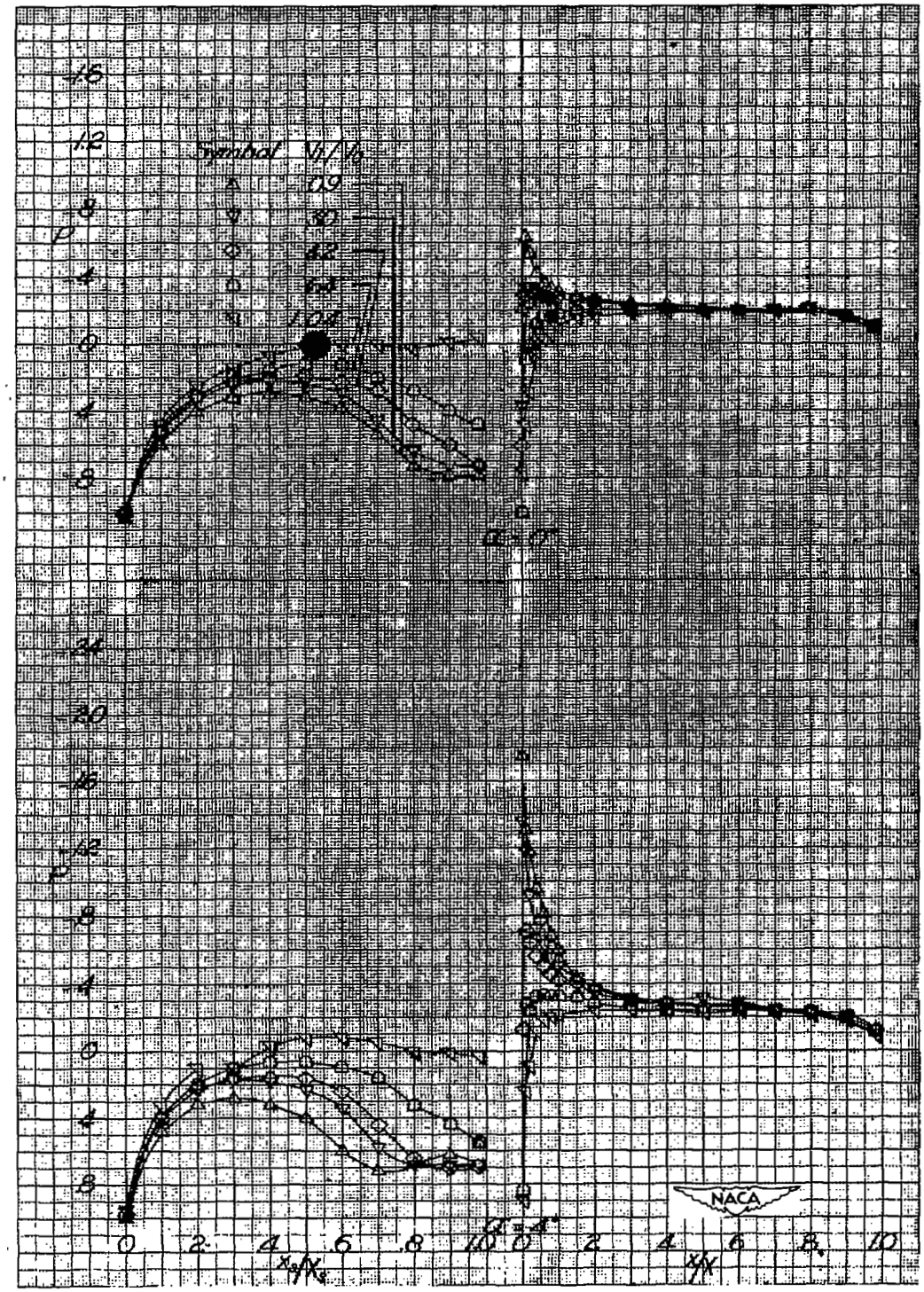


Figure 38.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-40-040 spinner.

Figure 38.- Concluded.

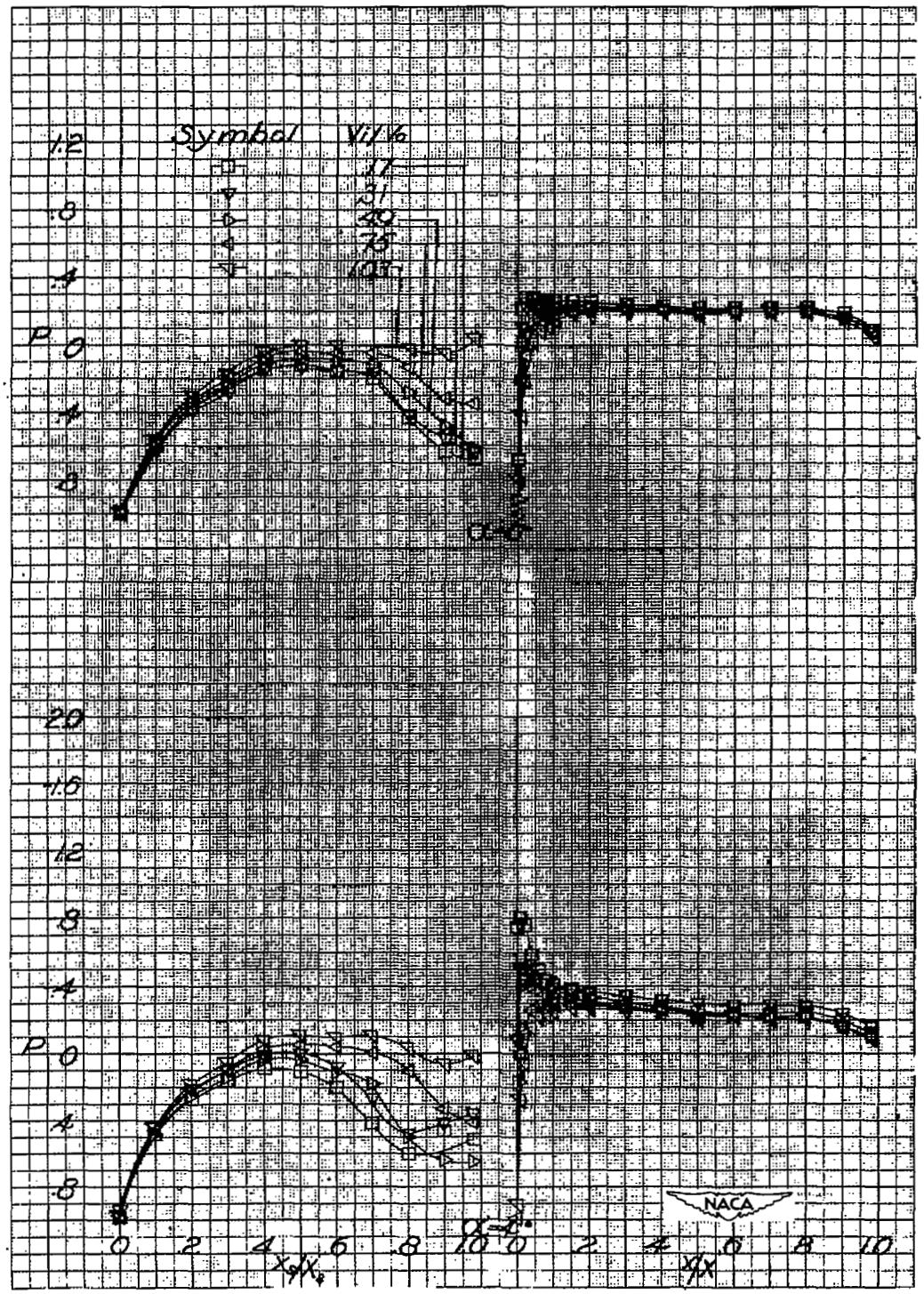


Figure 39.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-50-040 spinner.

Figure 39.- Concluded.

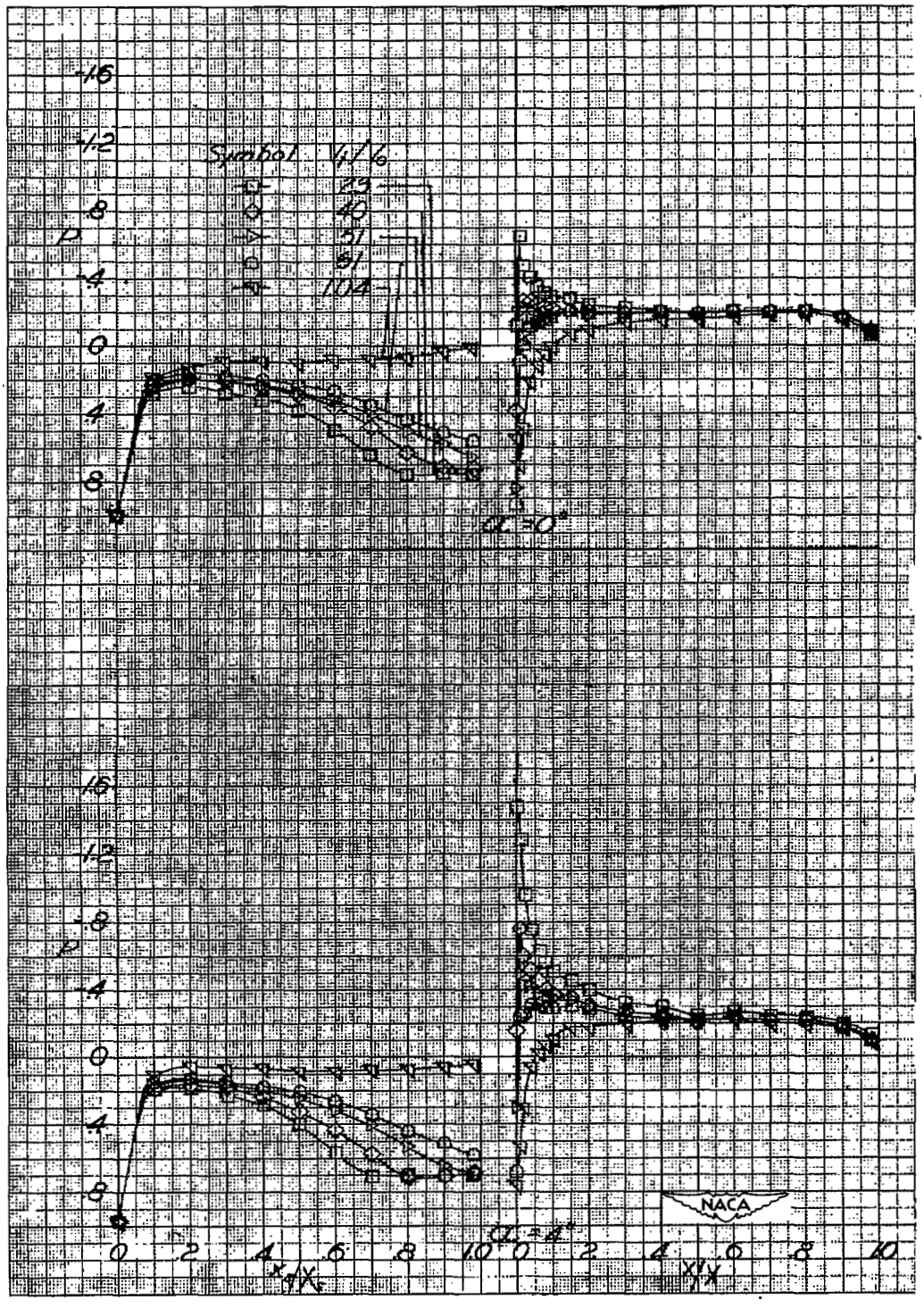


Figure 40.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-20-060 spinner.

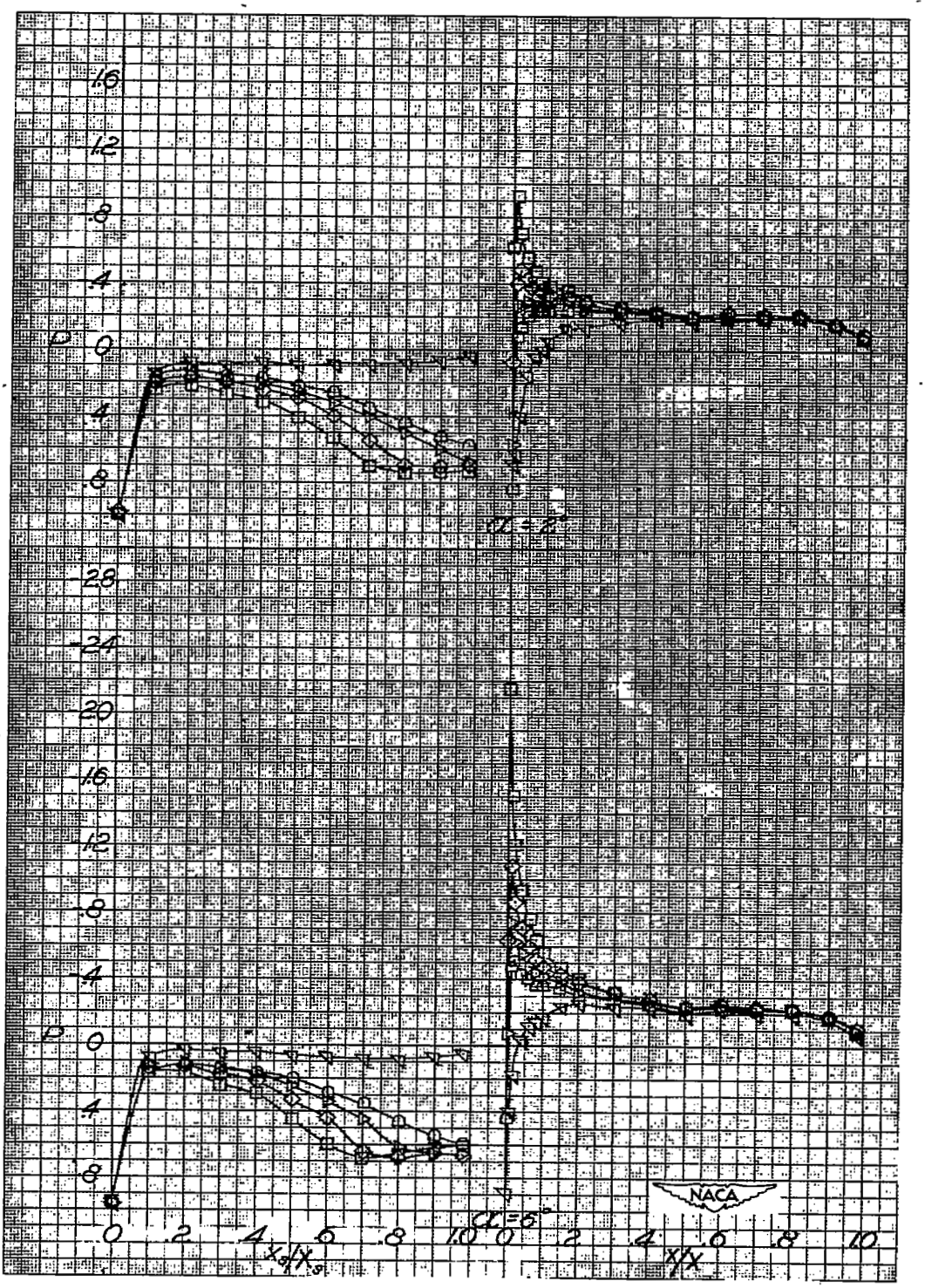


Figure 40.- Concluded.

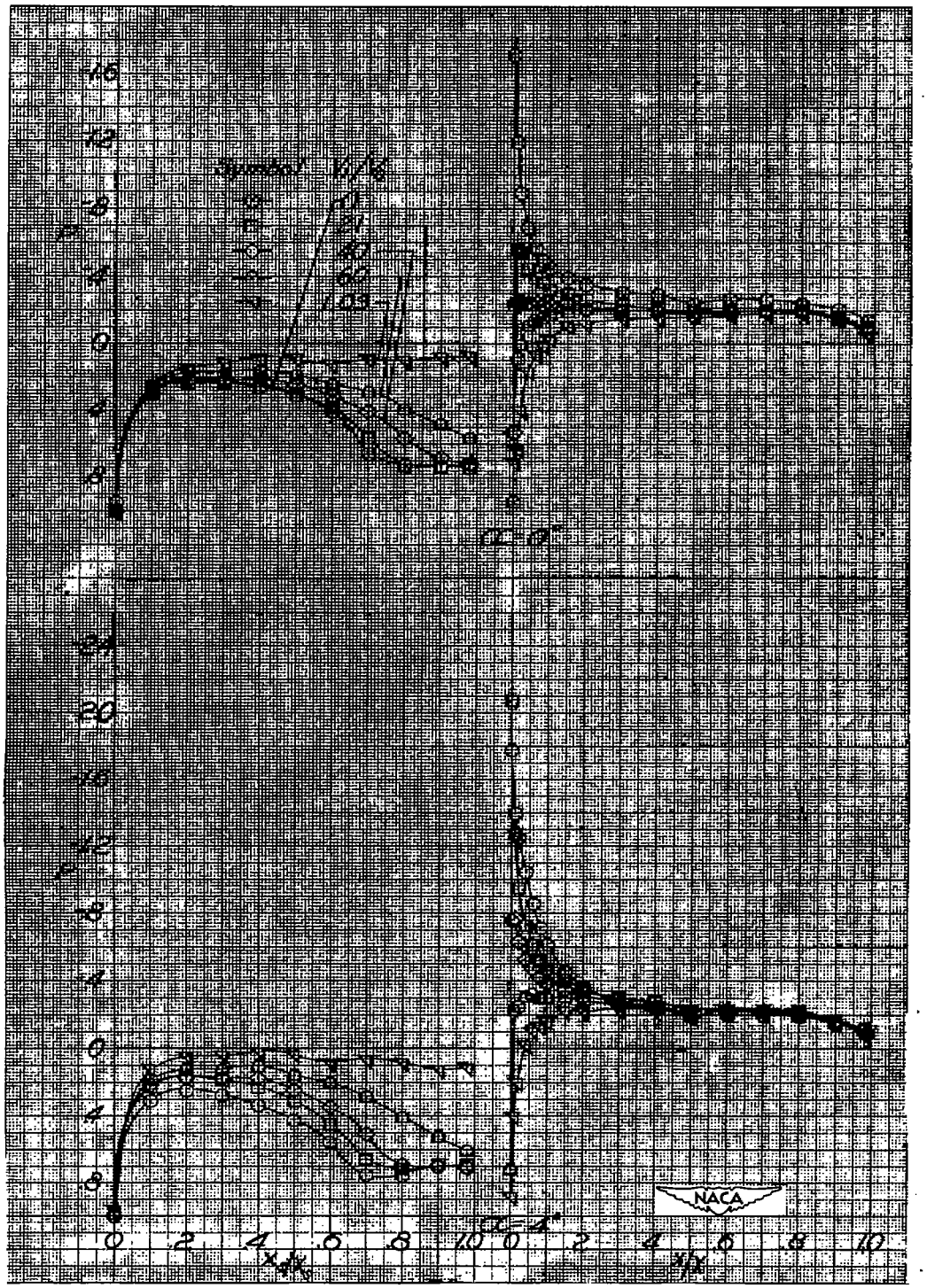


Figure 41.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-30-060 spinner.

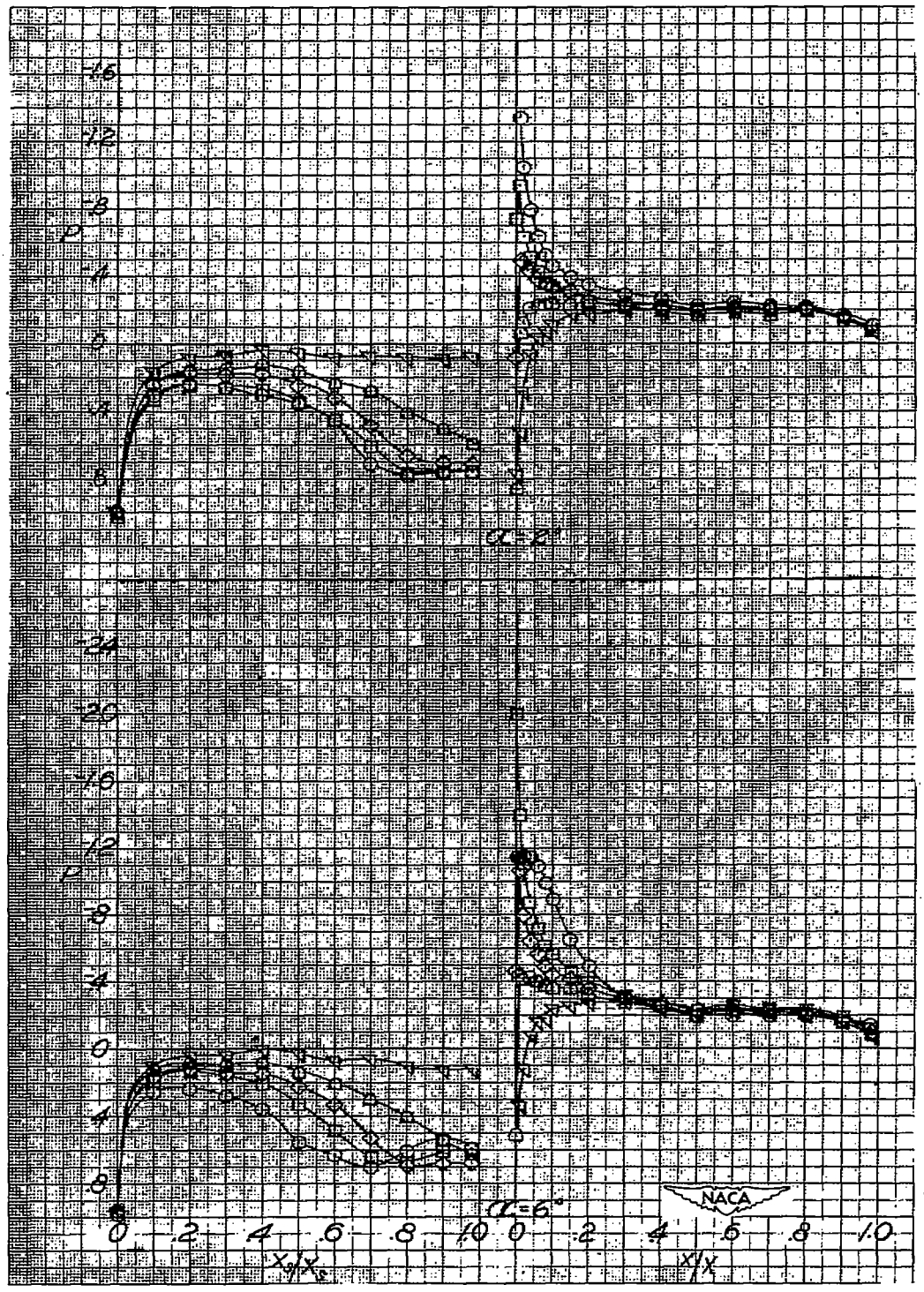


Figure 41.- Concluded.

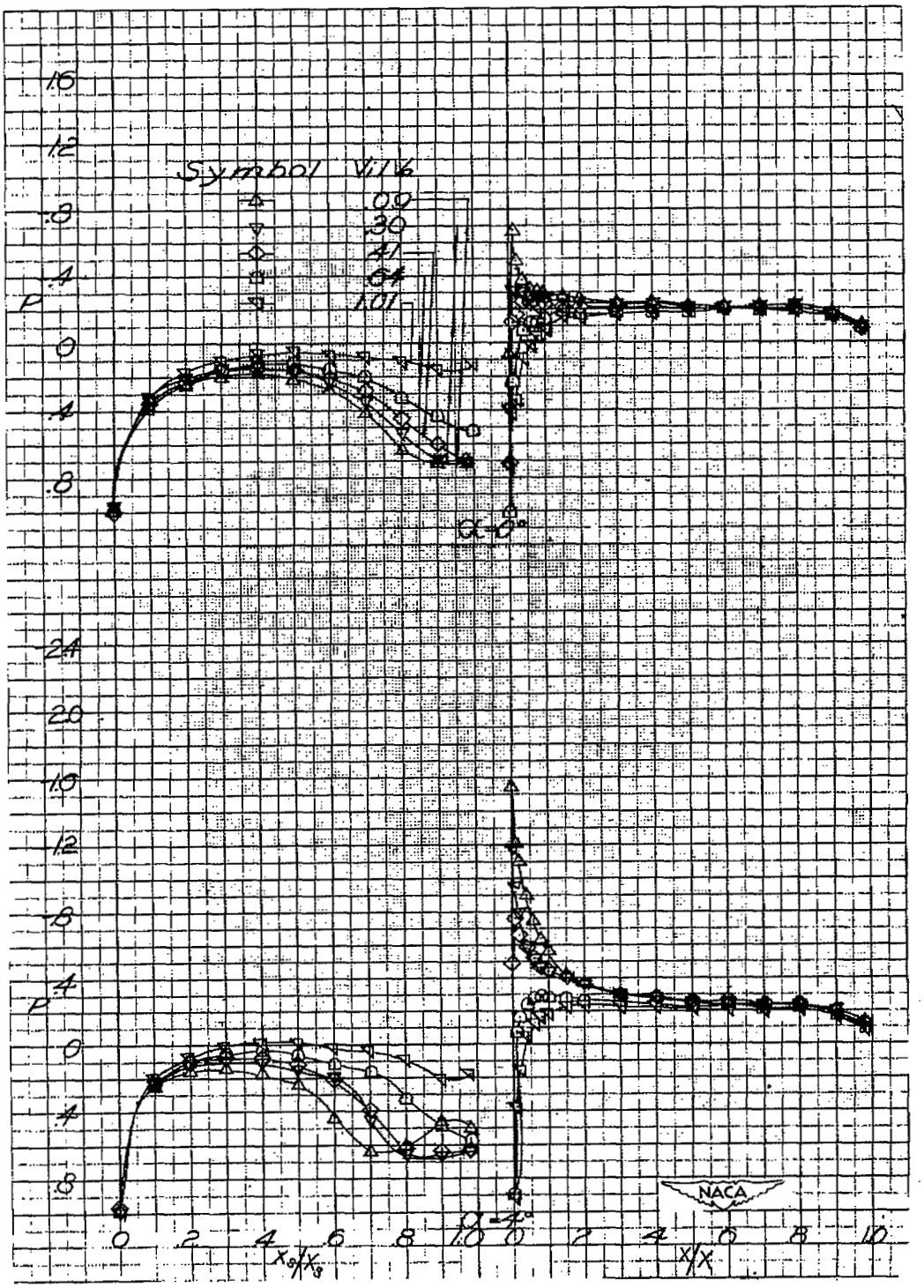


Figure 42.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-40-060 spinner.

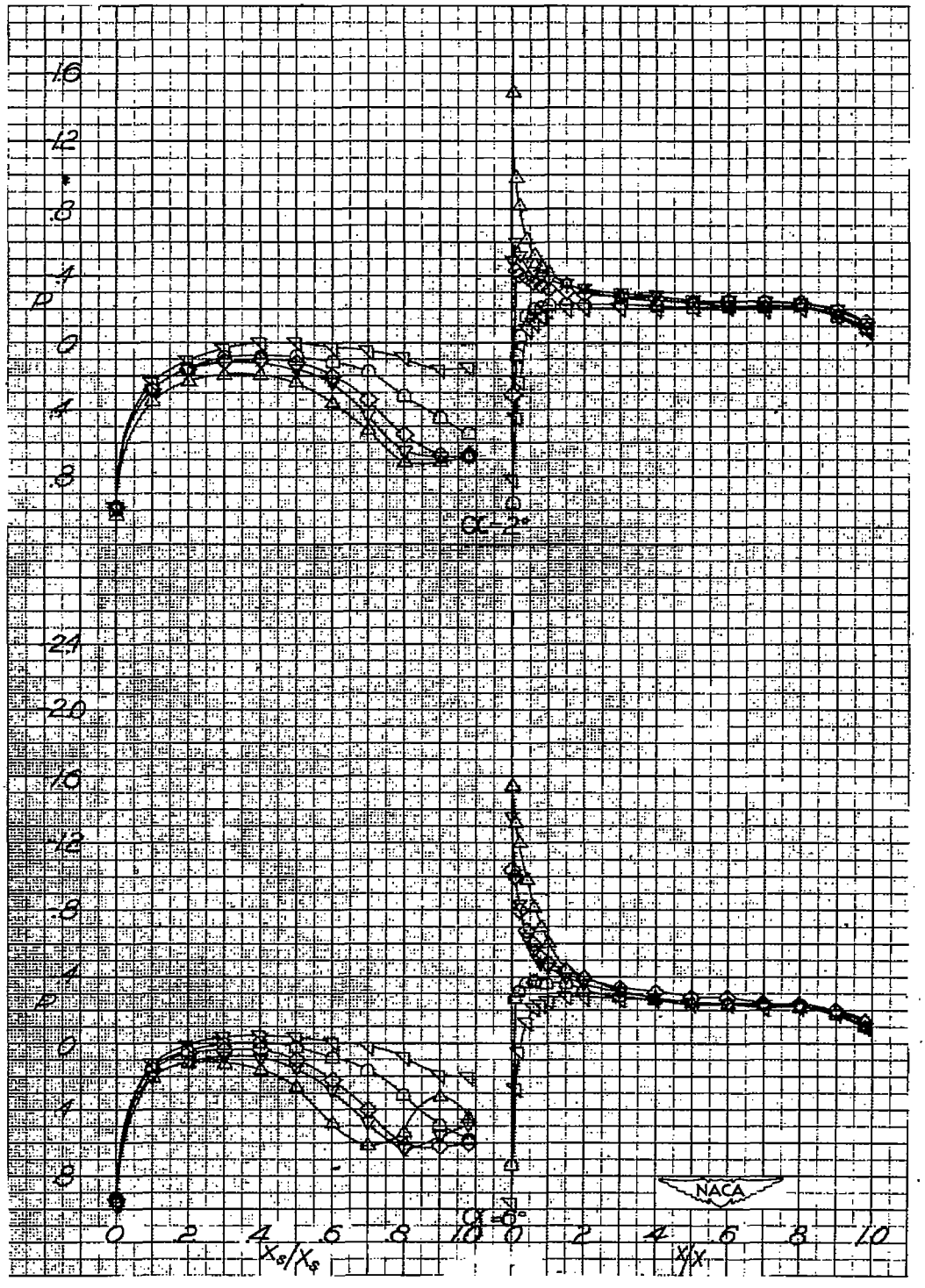


Figure 42.- Concluded.

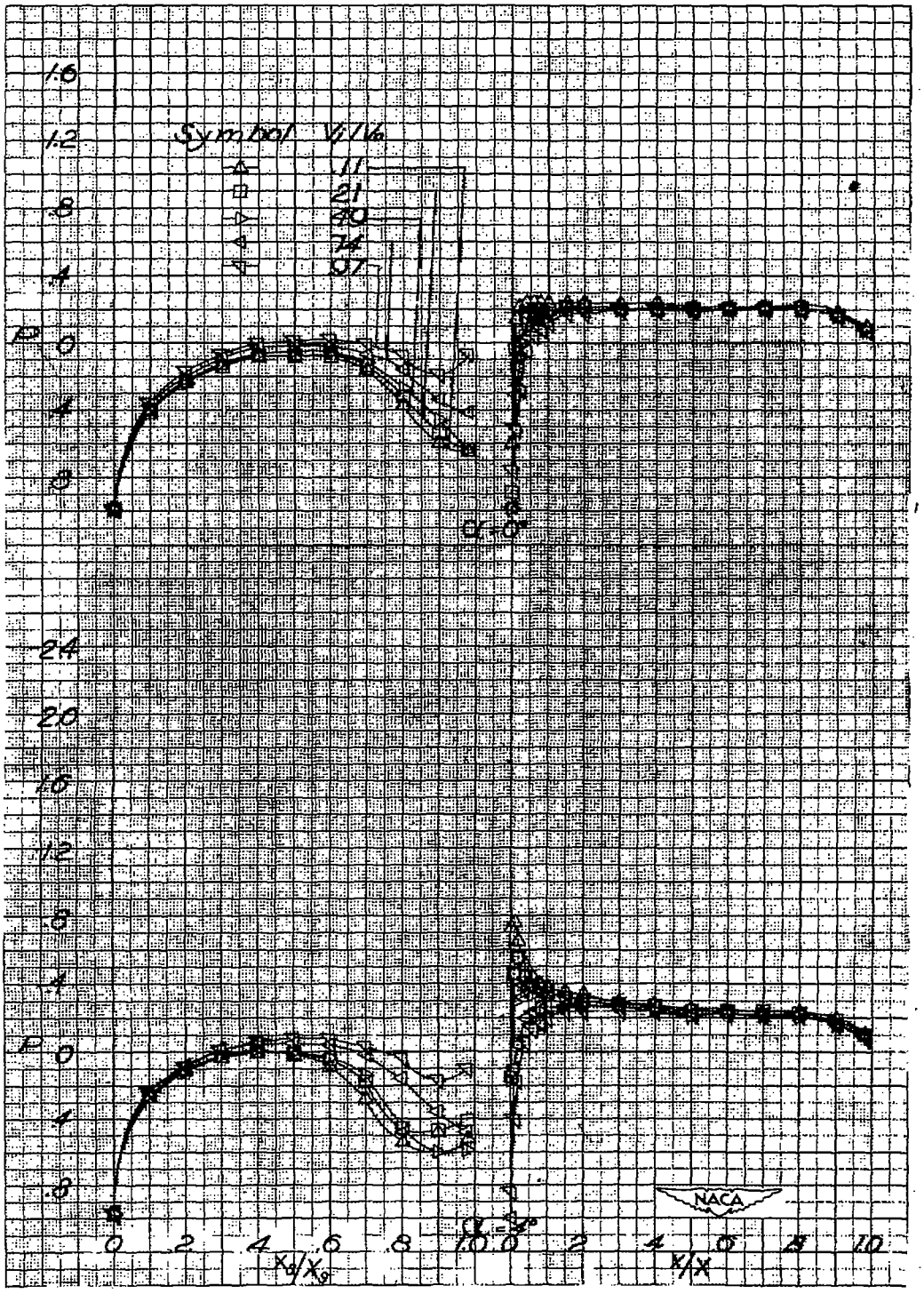


Figure 43.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-50-060 spinner.

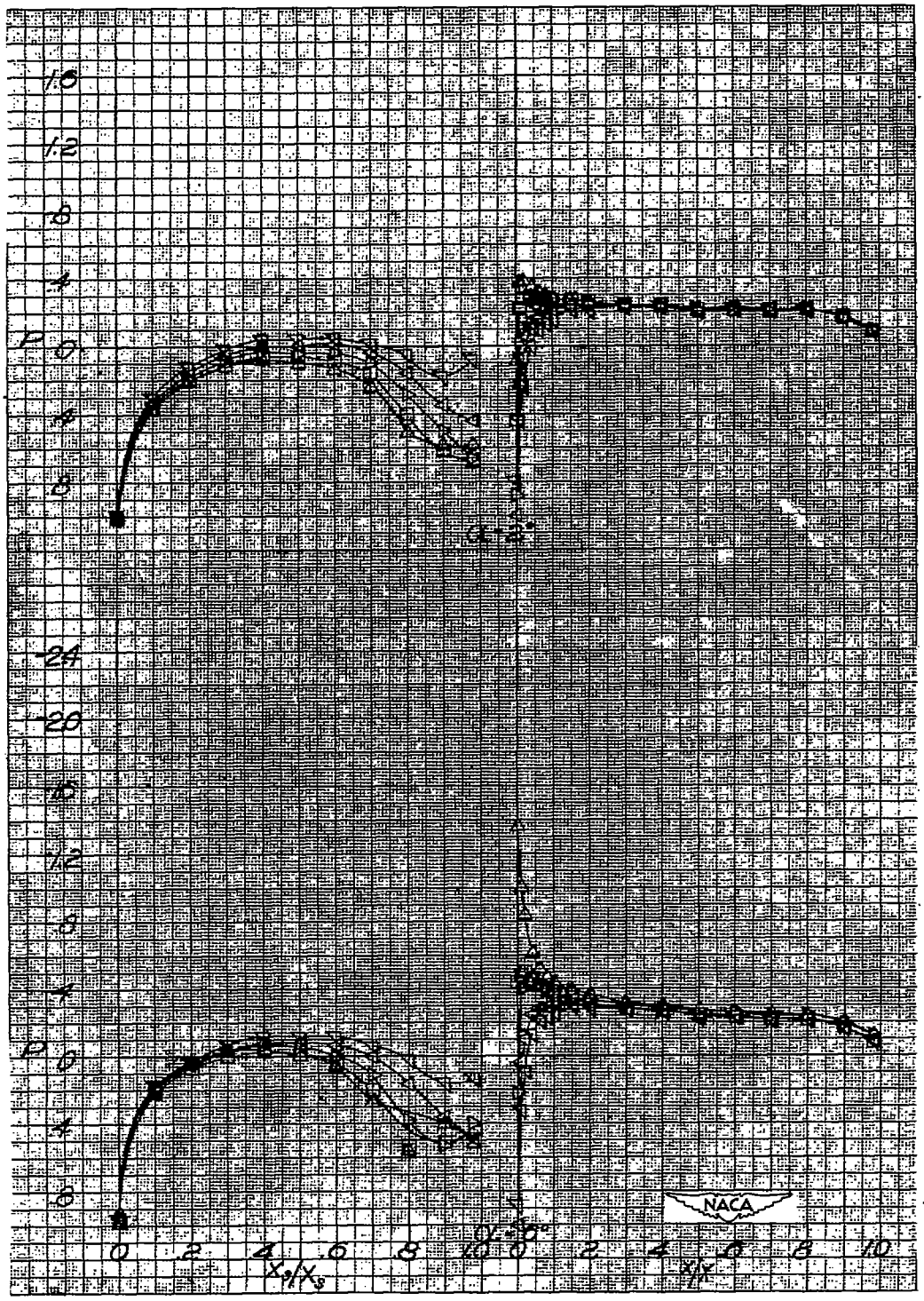


Figure 43.- Concluded.

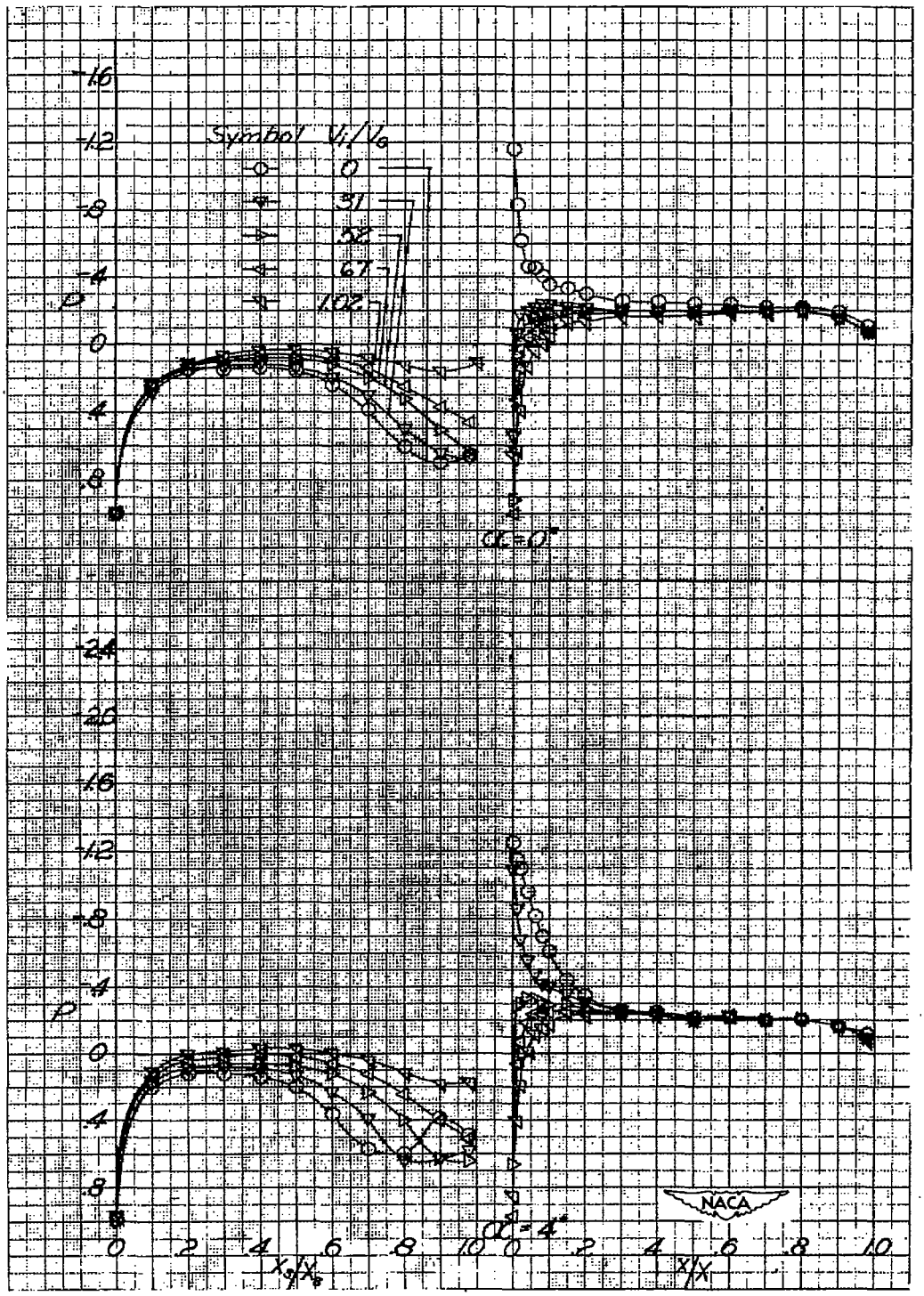


Figure 44.- Static-pressure distributions on top of NACA 1-60-100 cowling with NACA 1-40-080 spinner.

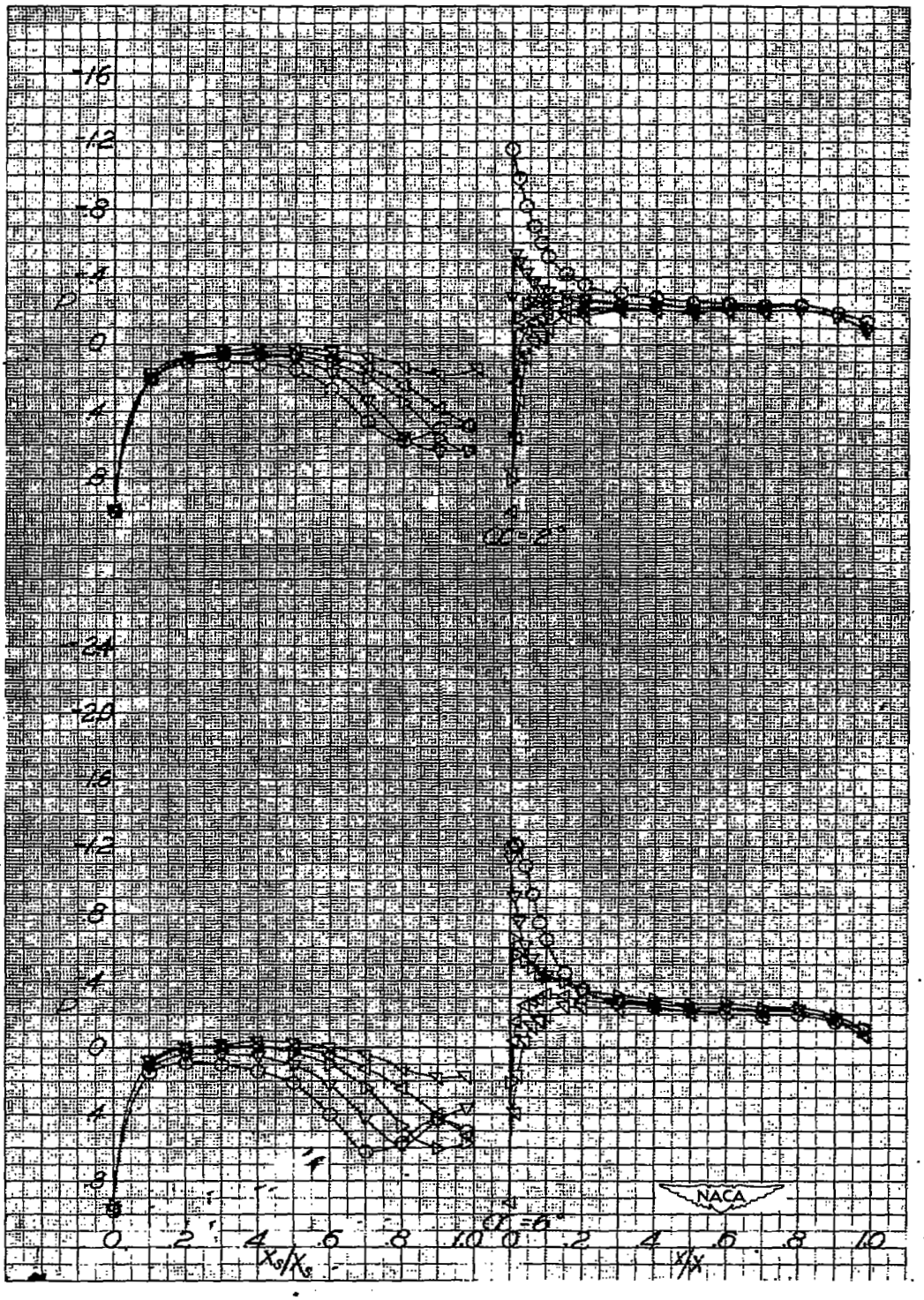


Figure 44.- Concluded.

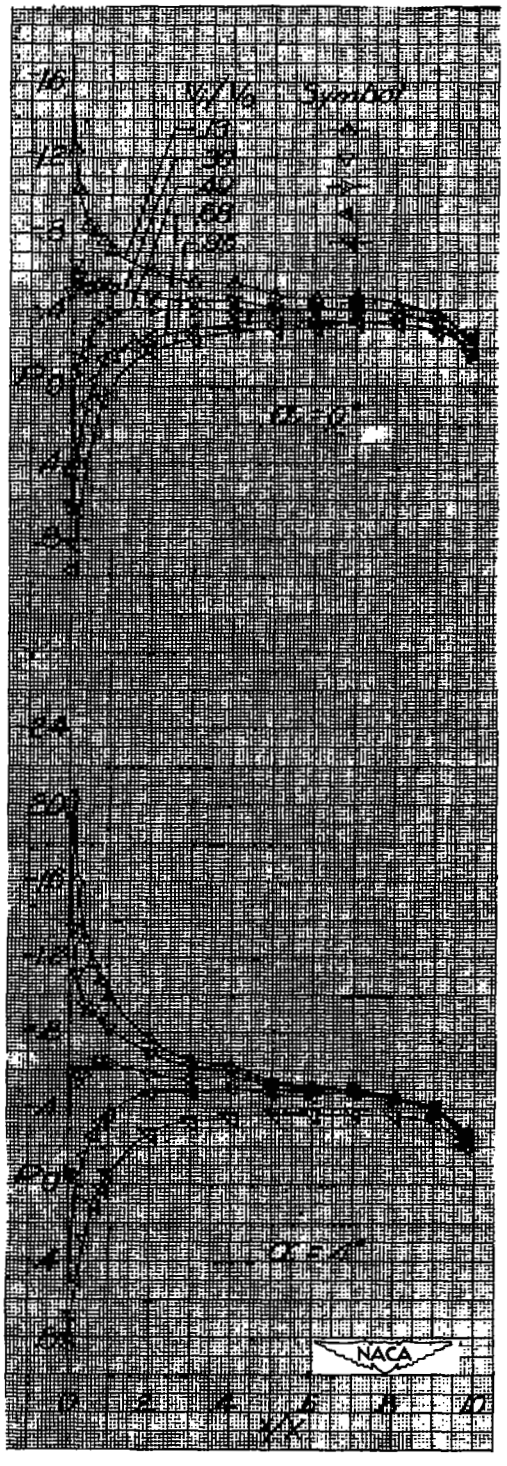
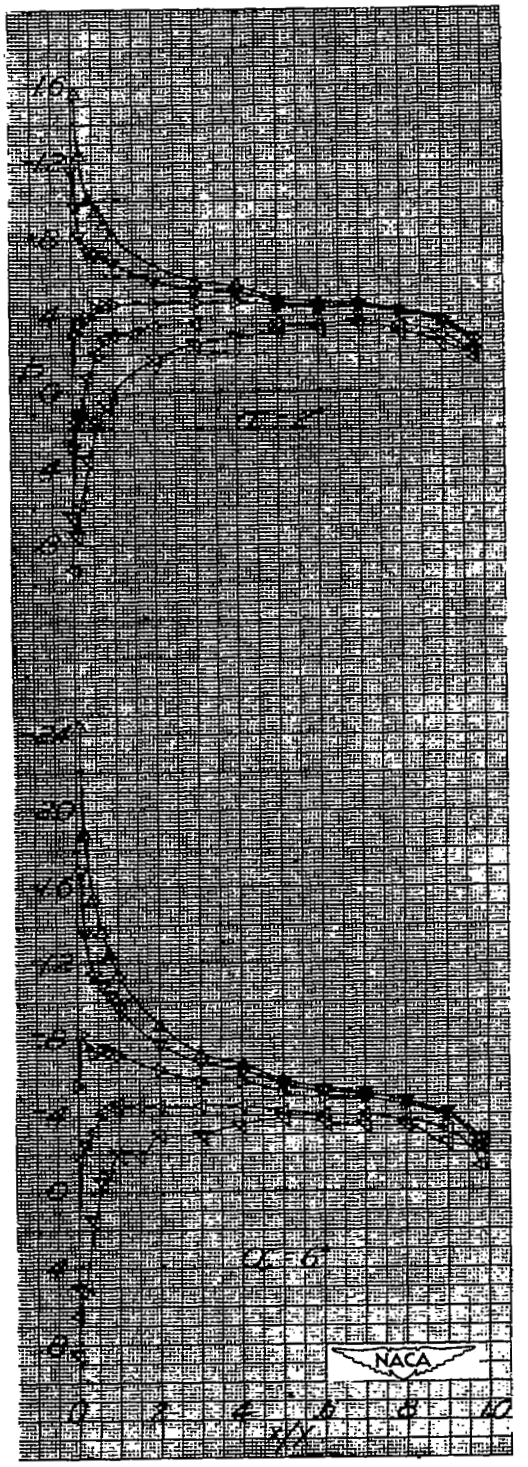


Figure 45.- Static-pressure distributions on top of NACA 1-70-050 open-nose cowling.



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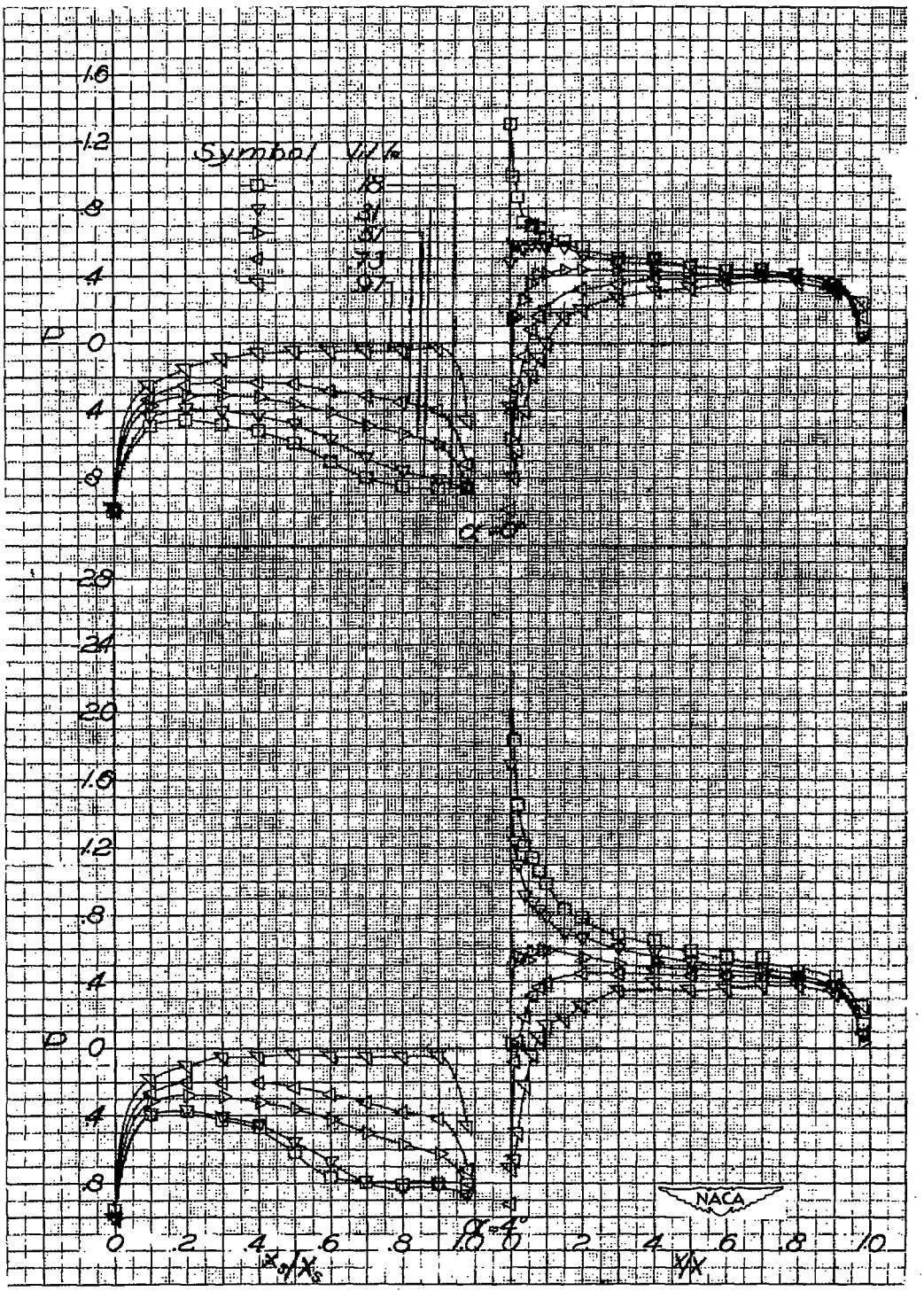


Figure 46.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-20-040 spinner.

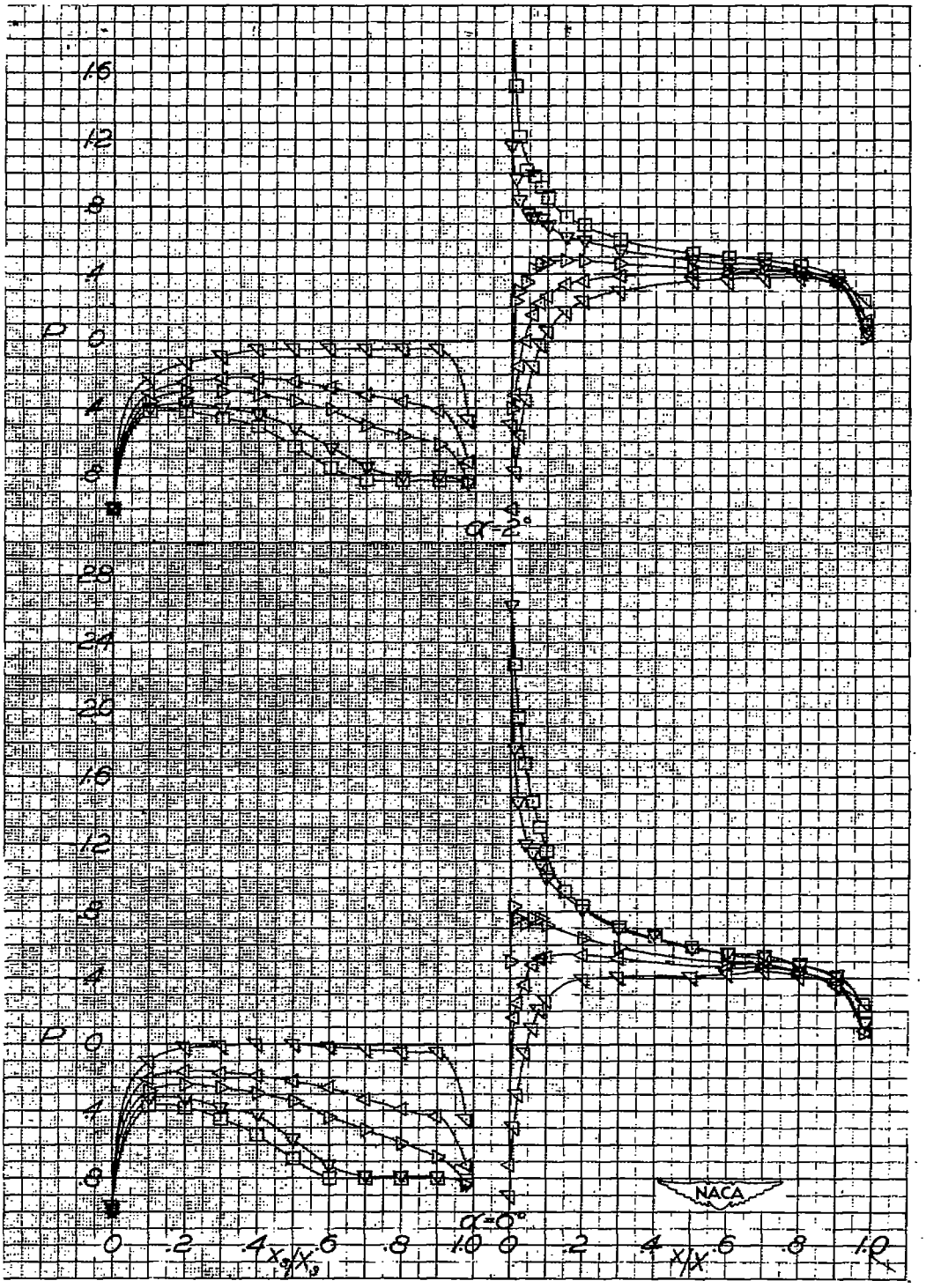


Figure 46.- Concluded.

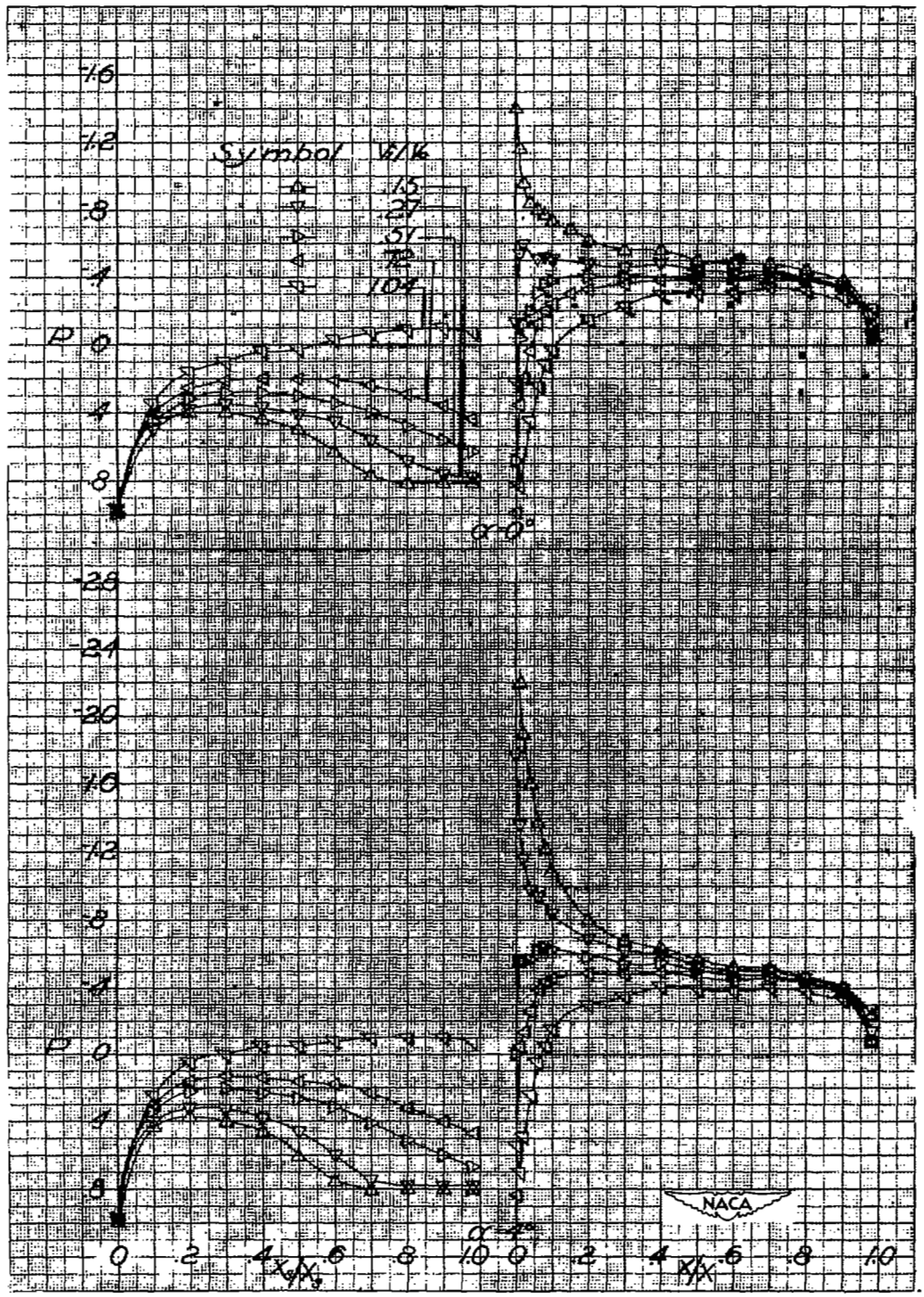


Figure 47.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-30-040 spinner.

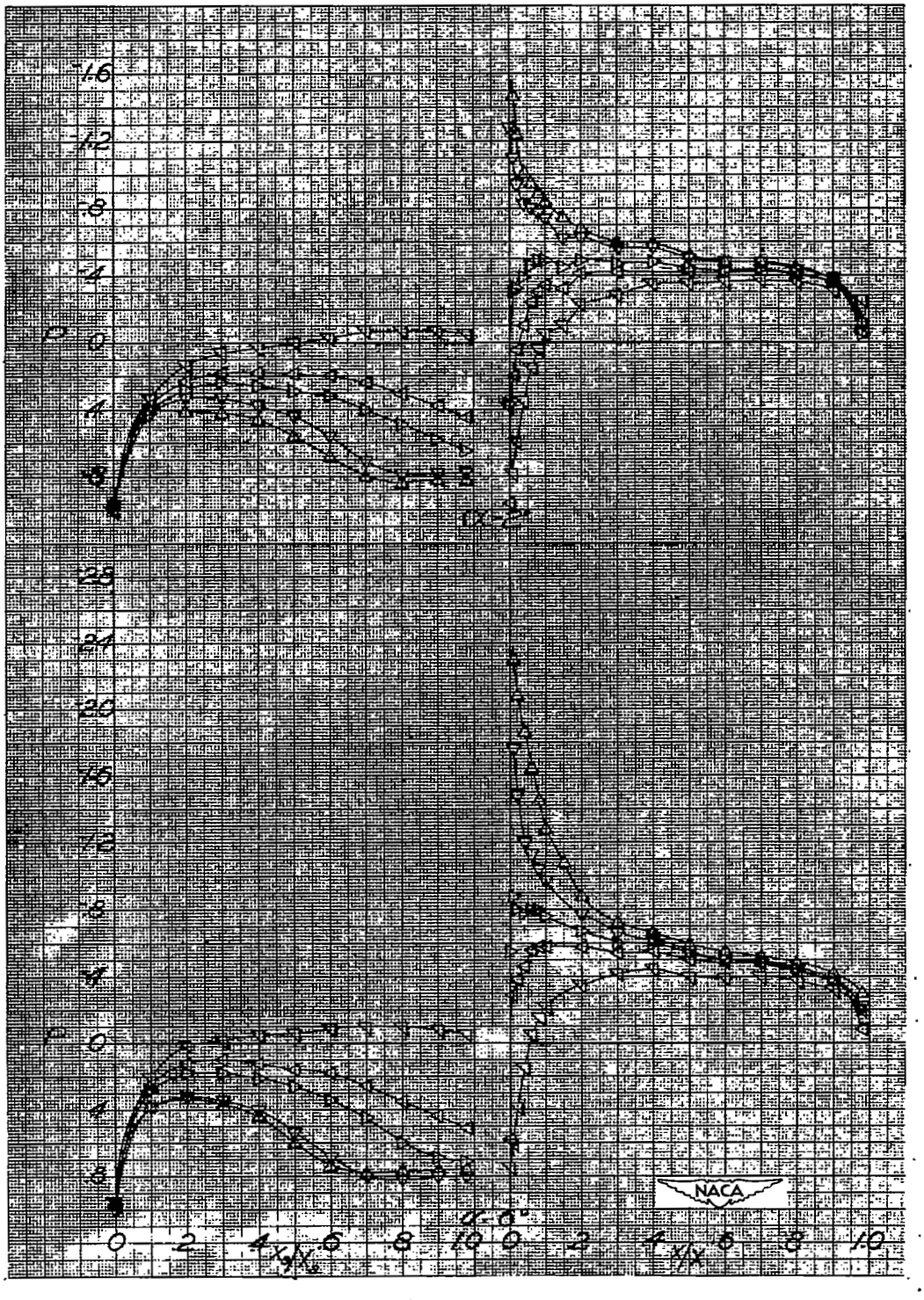


Figure 47.- Concluded.

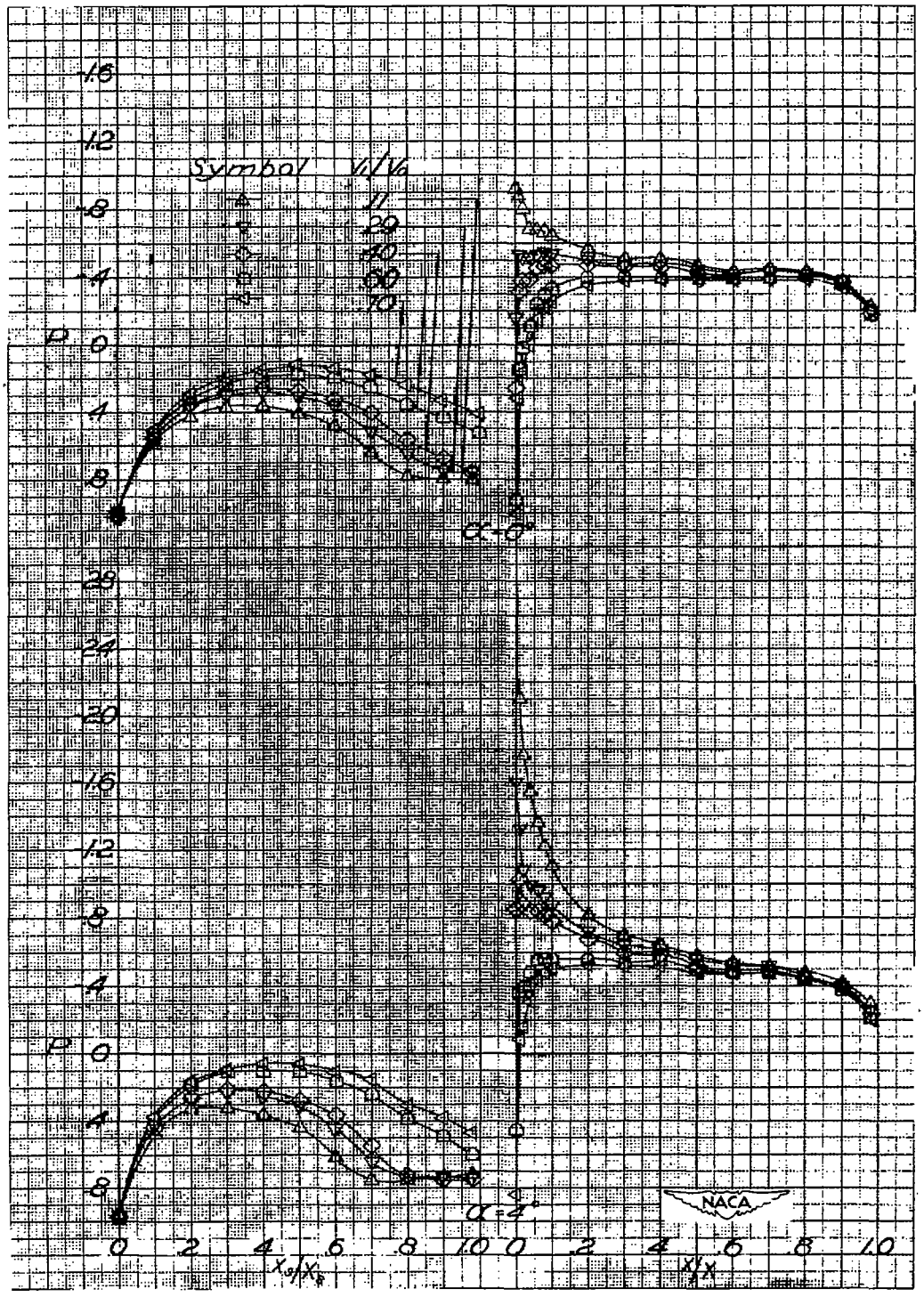
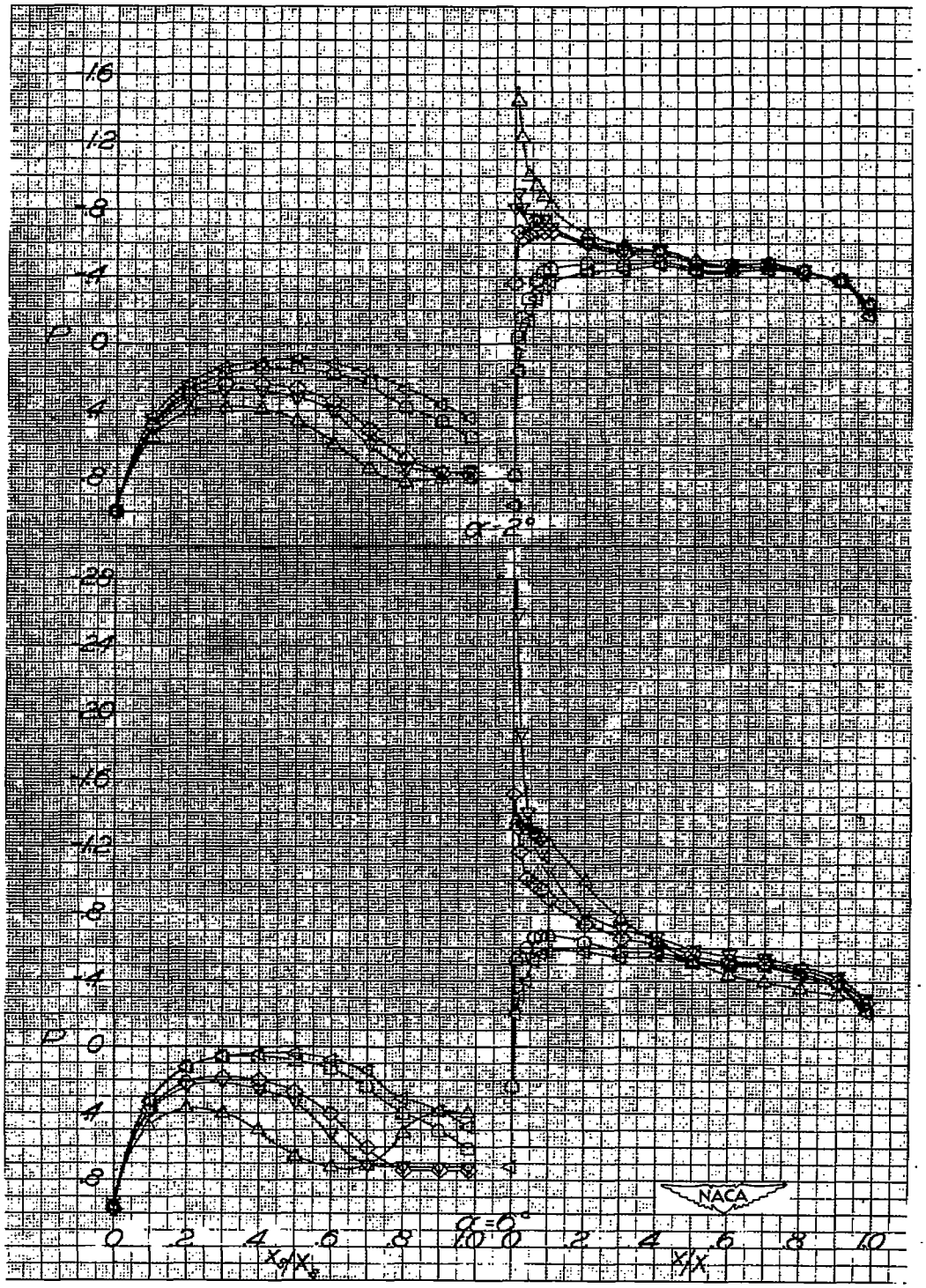


Figure 48.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-40-040 spinner.



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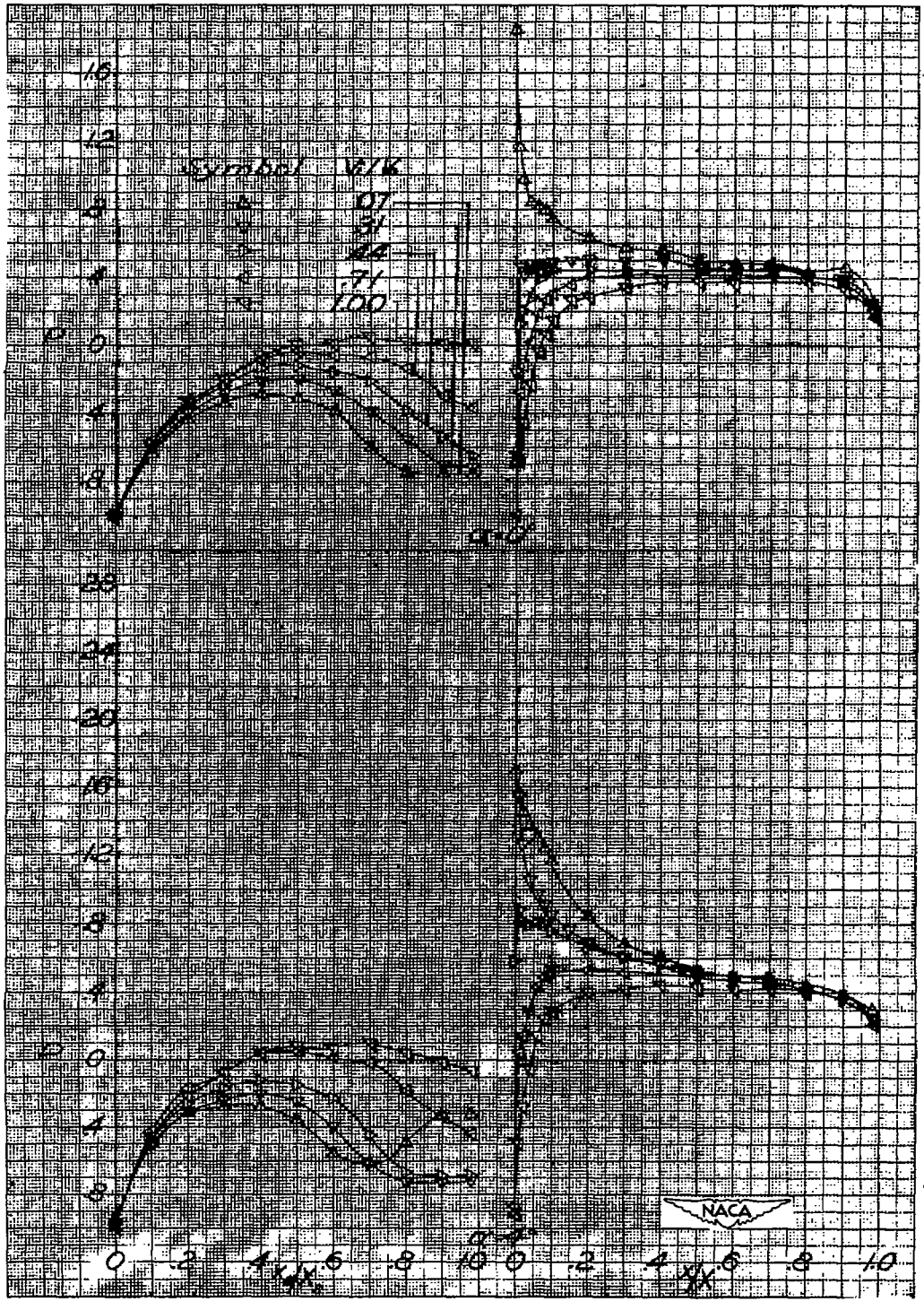


Figure 49.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-50-040 spinner.

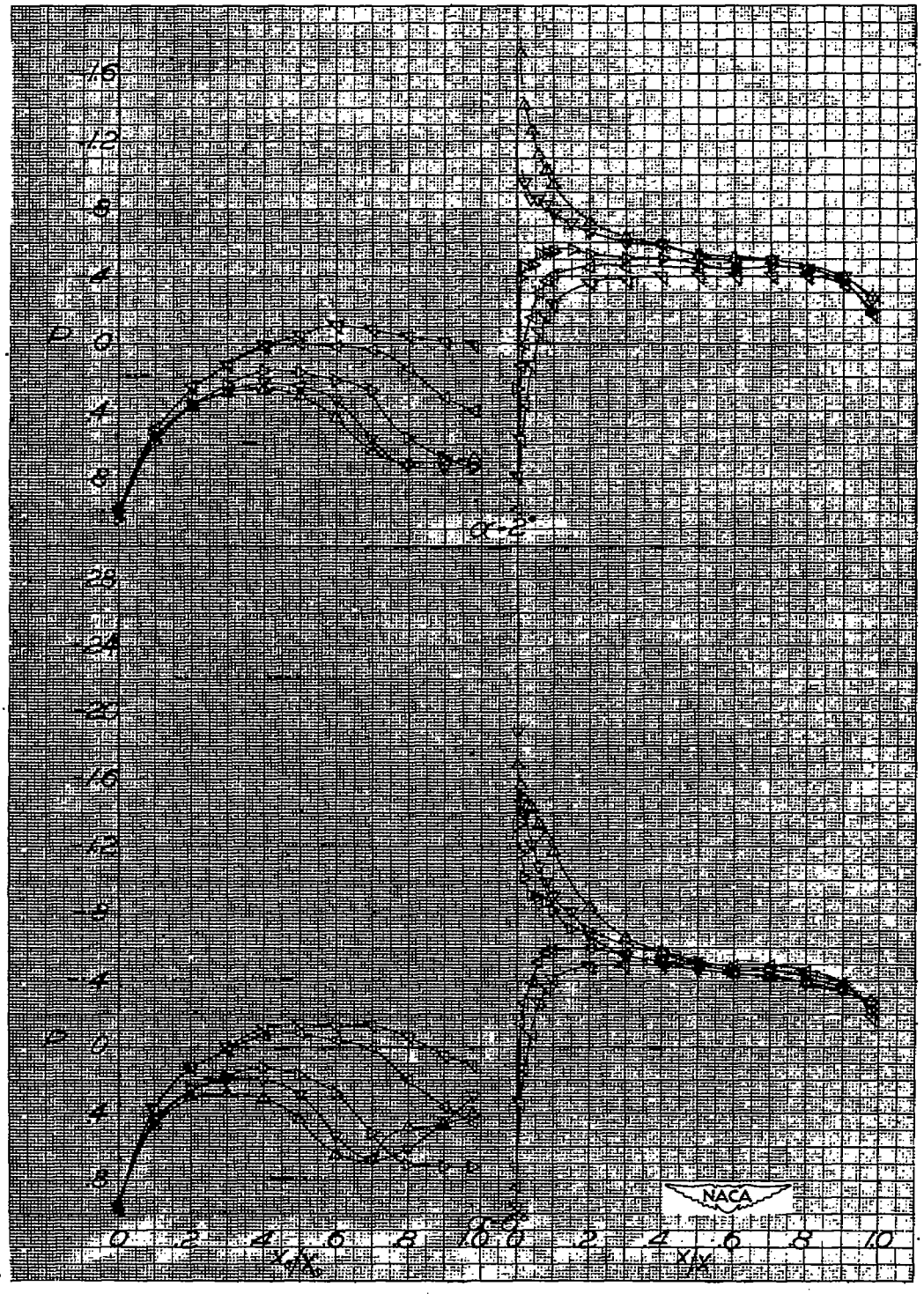


Figure 49.- Concluded.

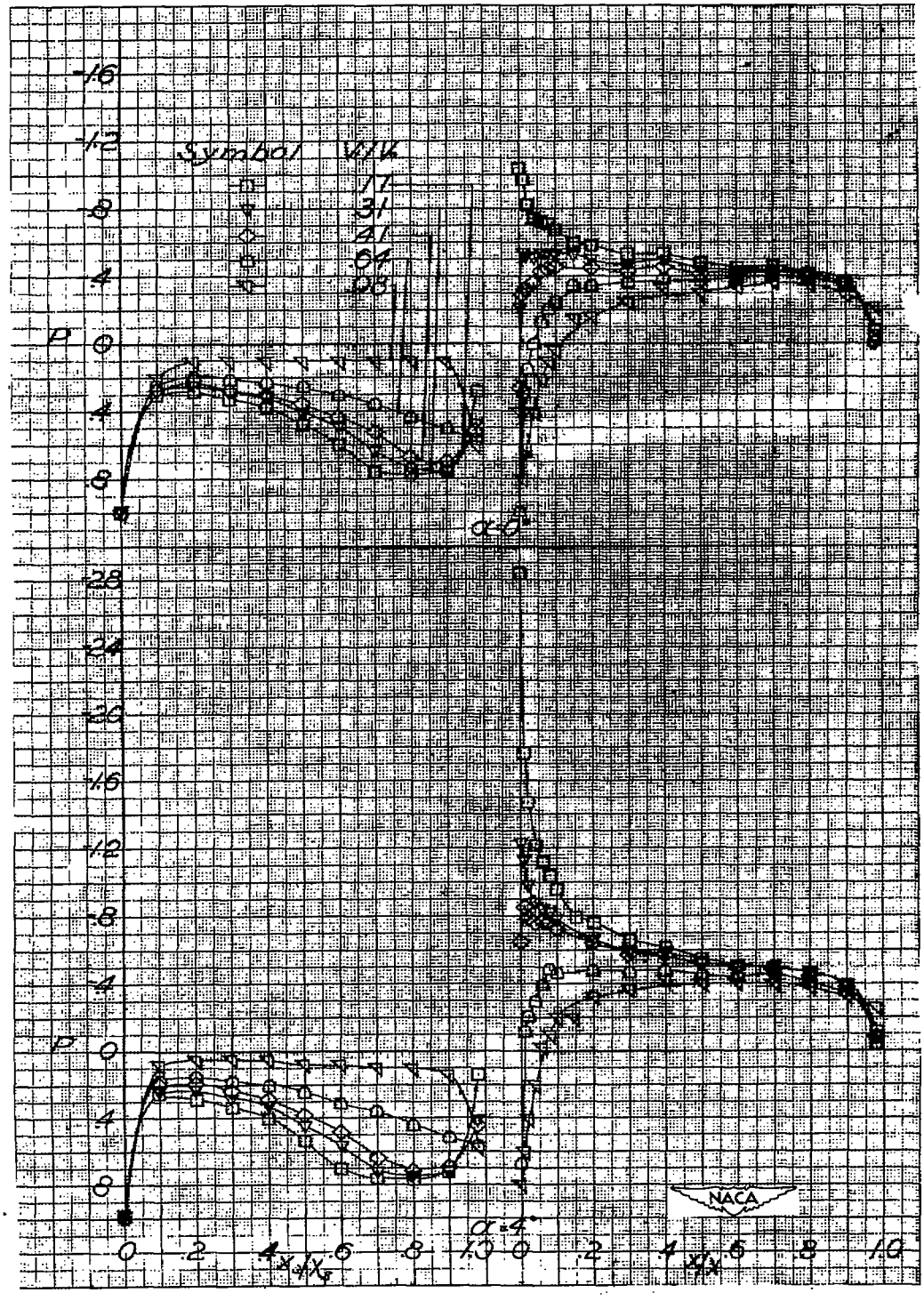
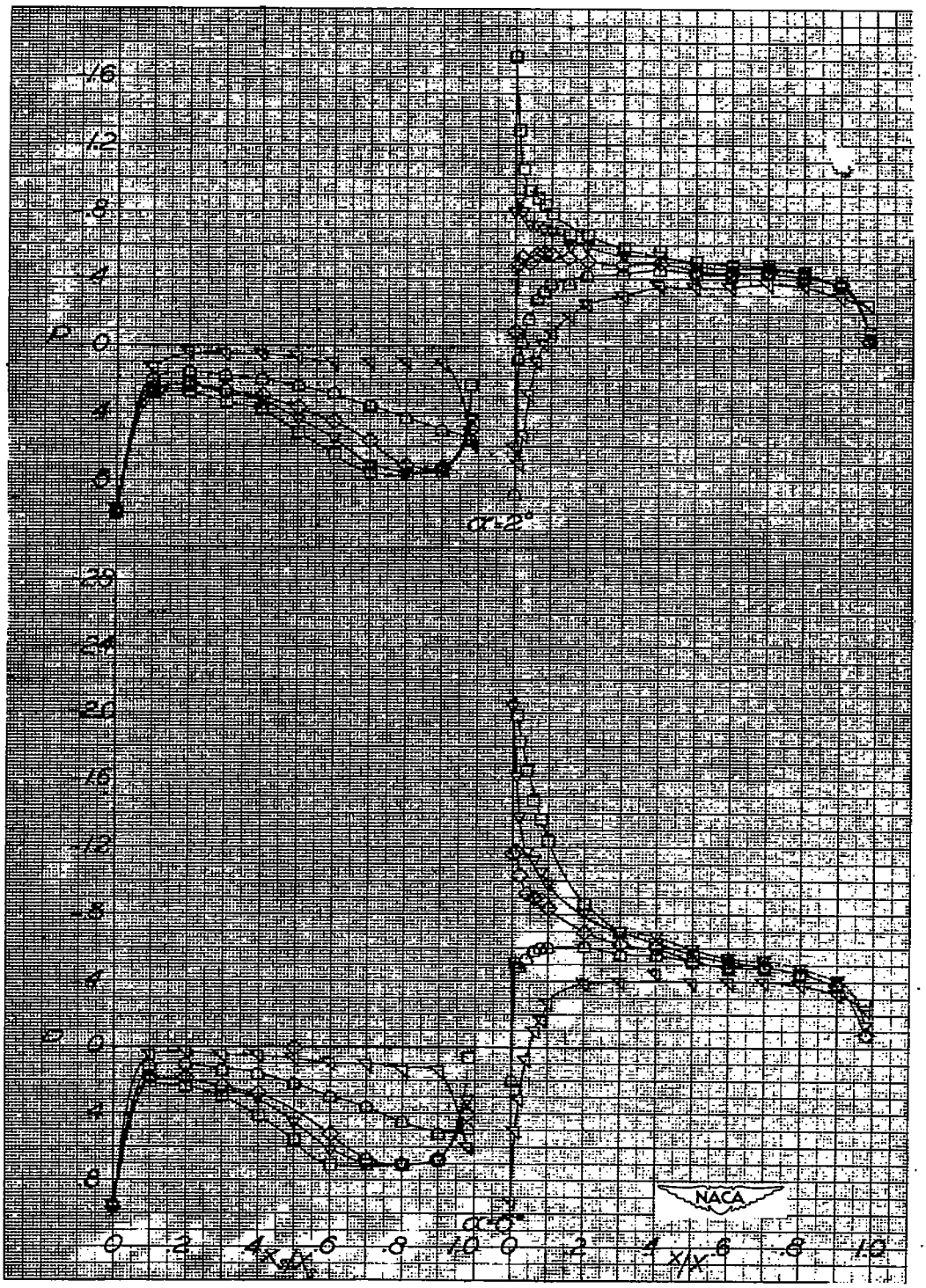


Figure 50.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-20-060 spinner.



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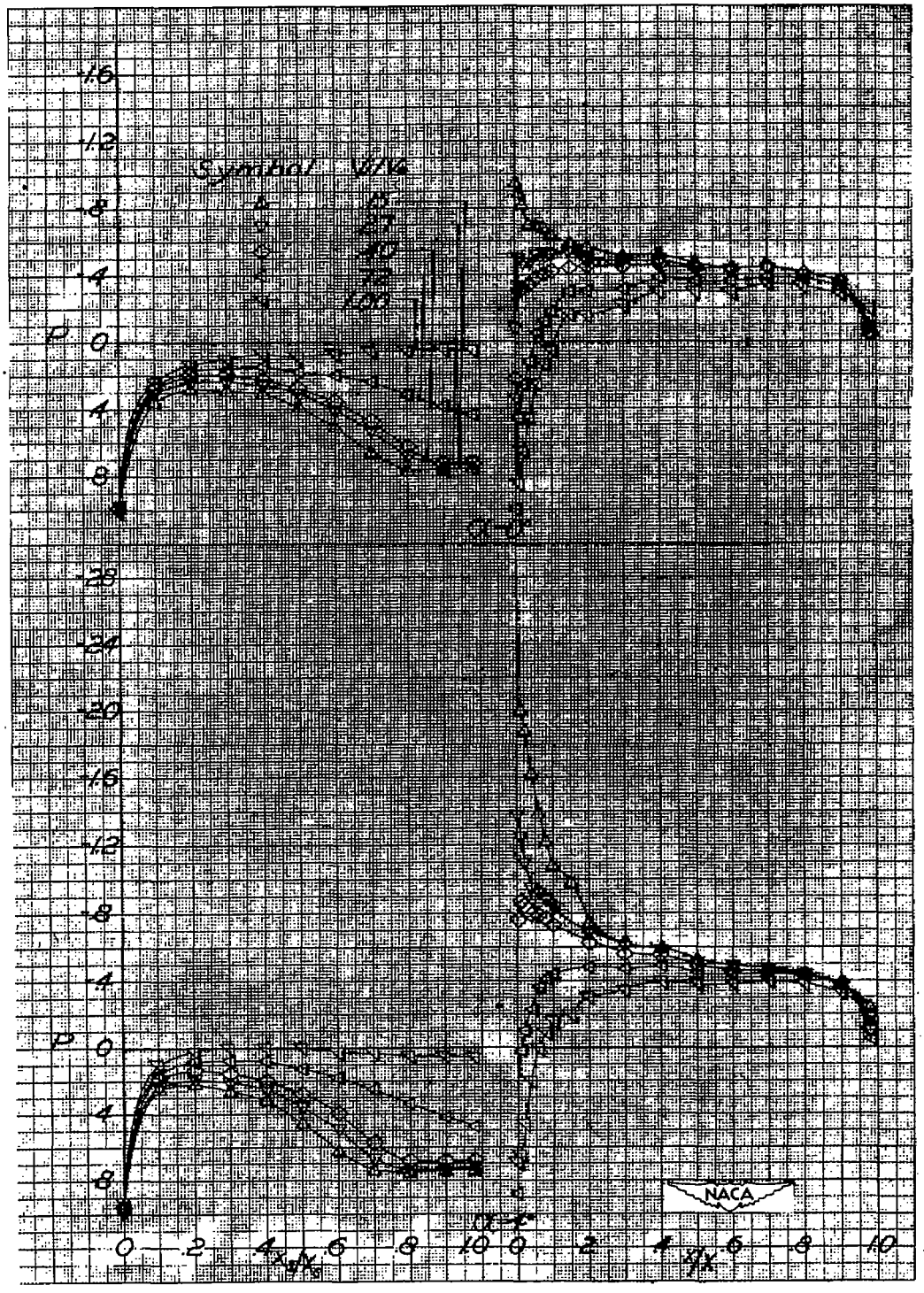


Figure 51.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-30-060 spinner.

Figure 51.- Concluded.

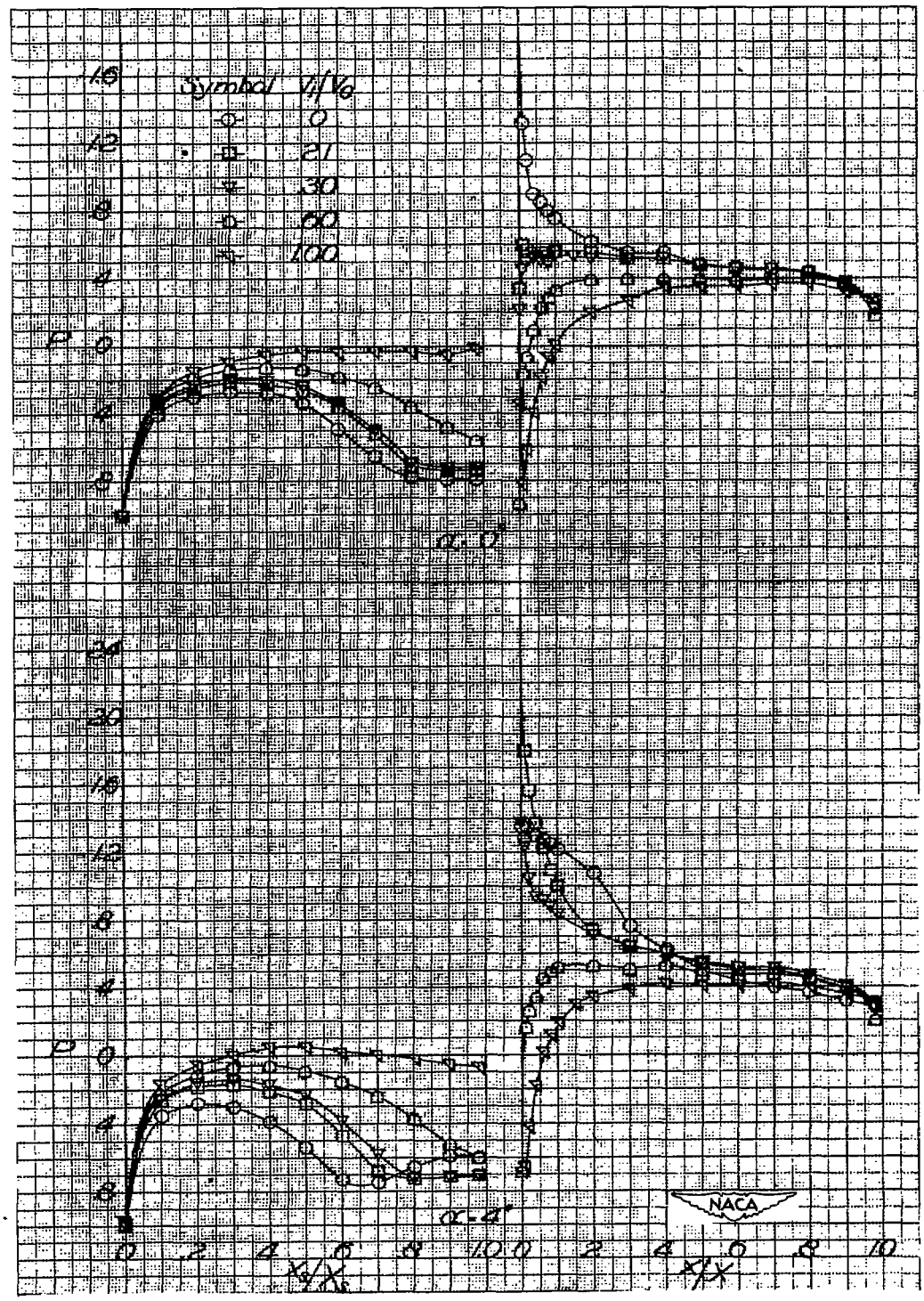


Figure 52.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-40-060 spinner.

Figure 52.- Concluded.

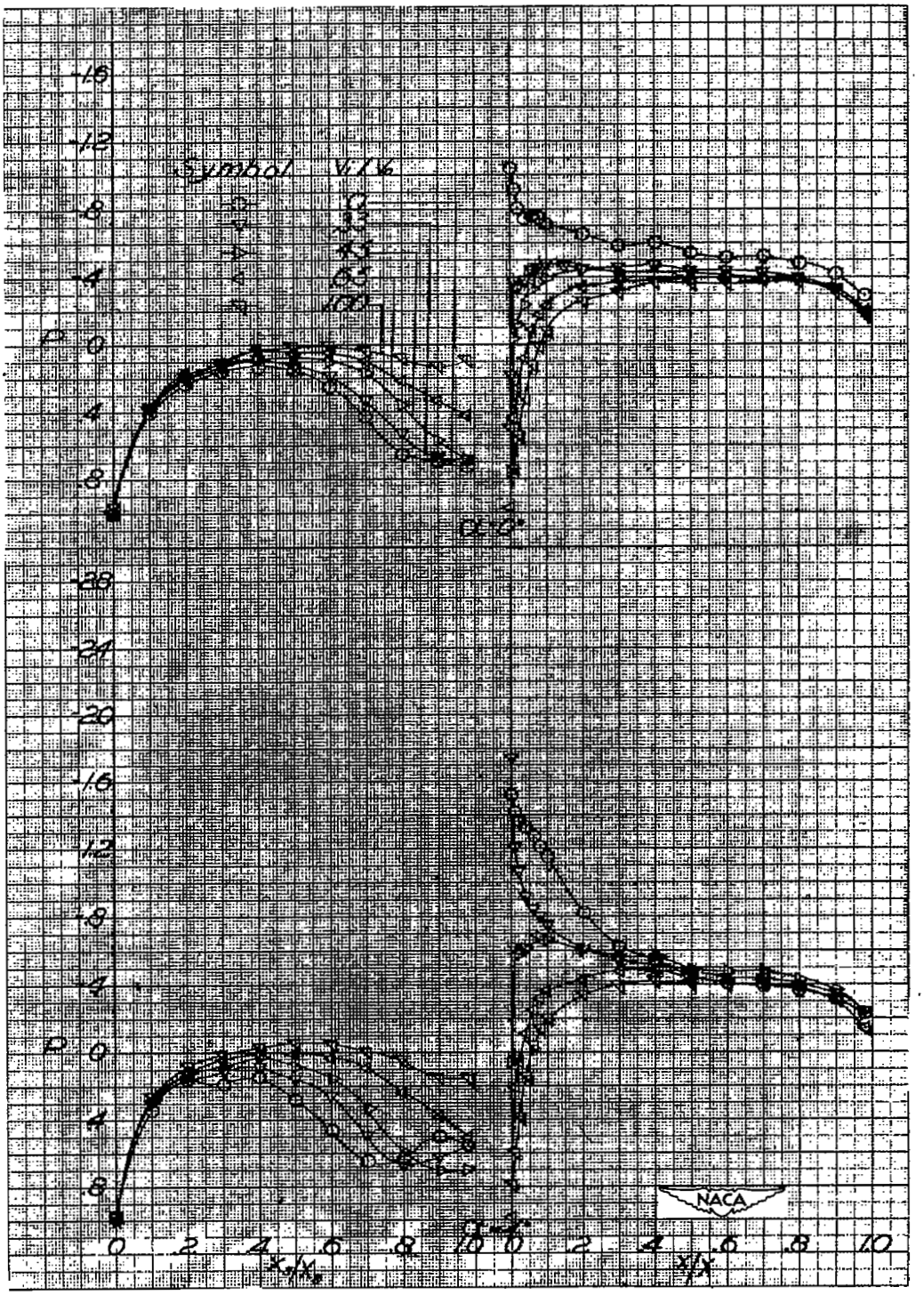
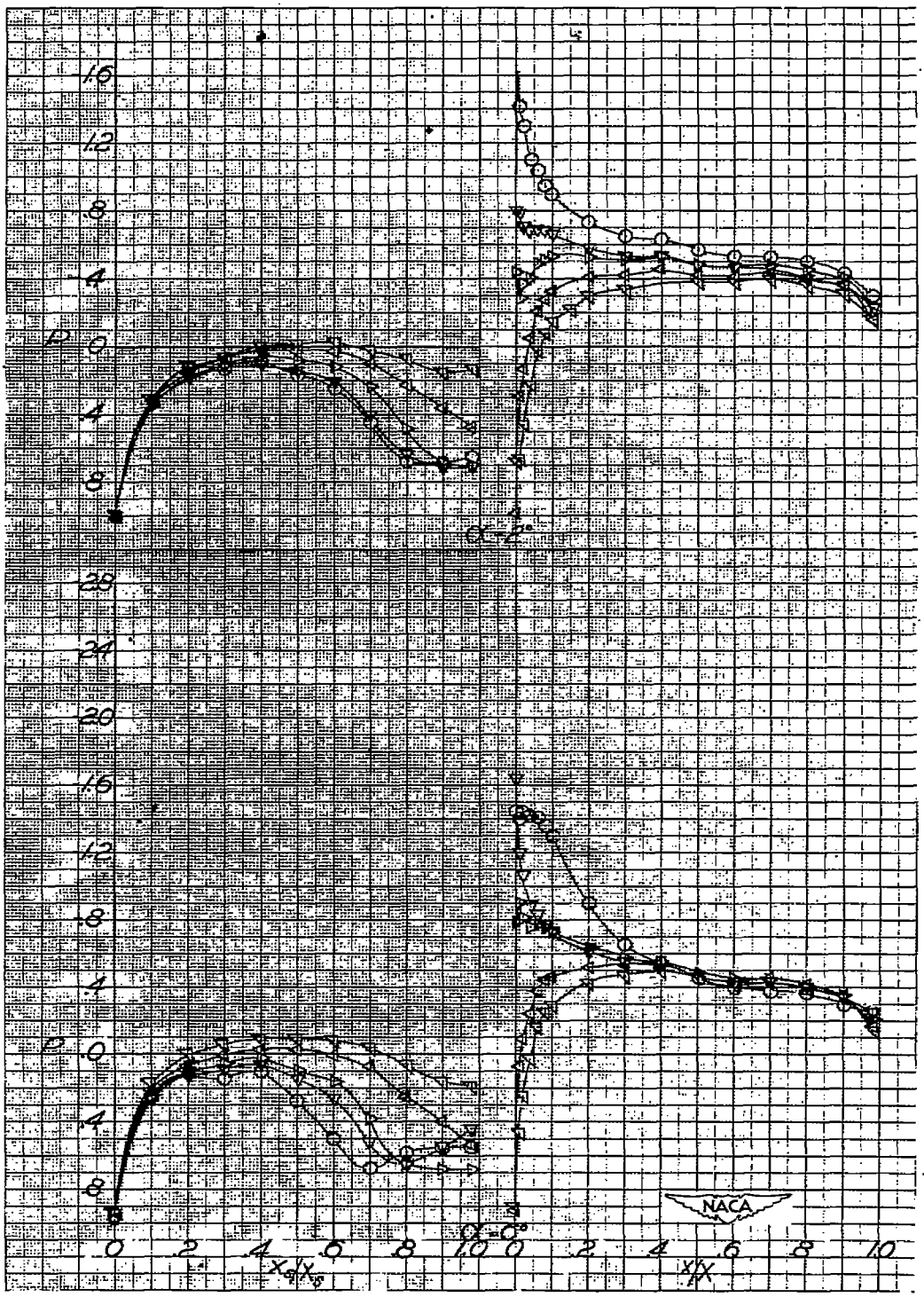


Figure 53.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-50-060 spinner.



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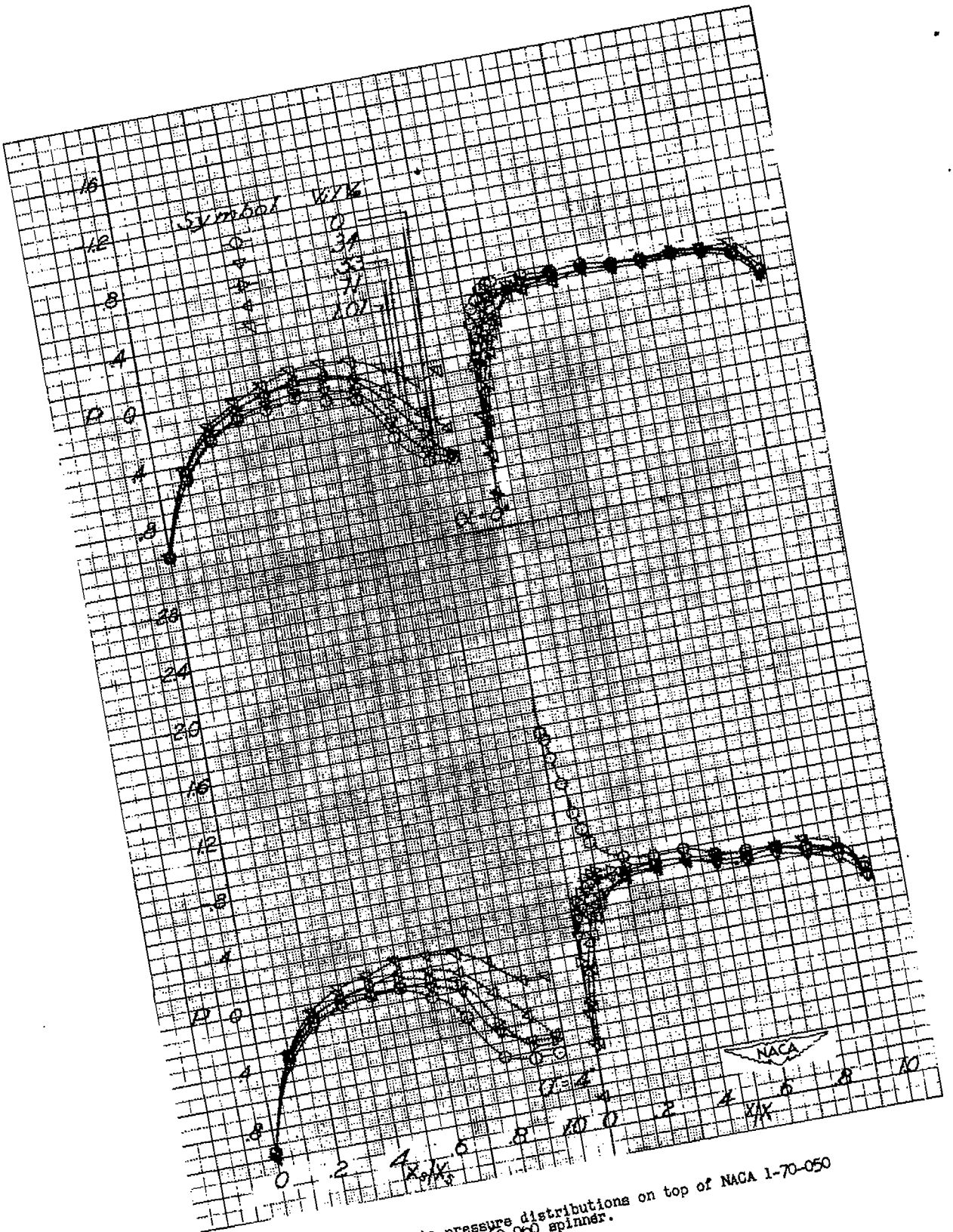


Figure 54.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-60-060 spinner.

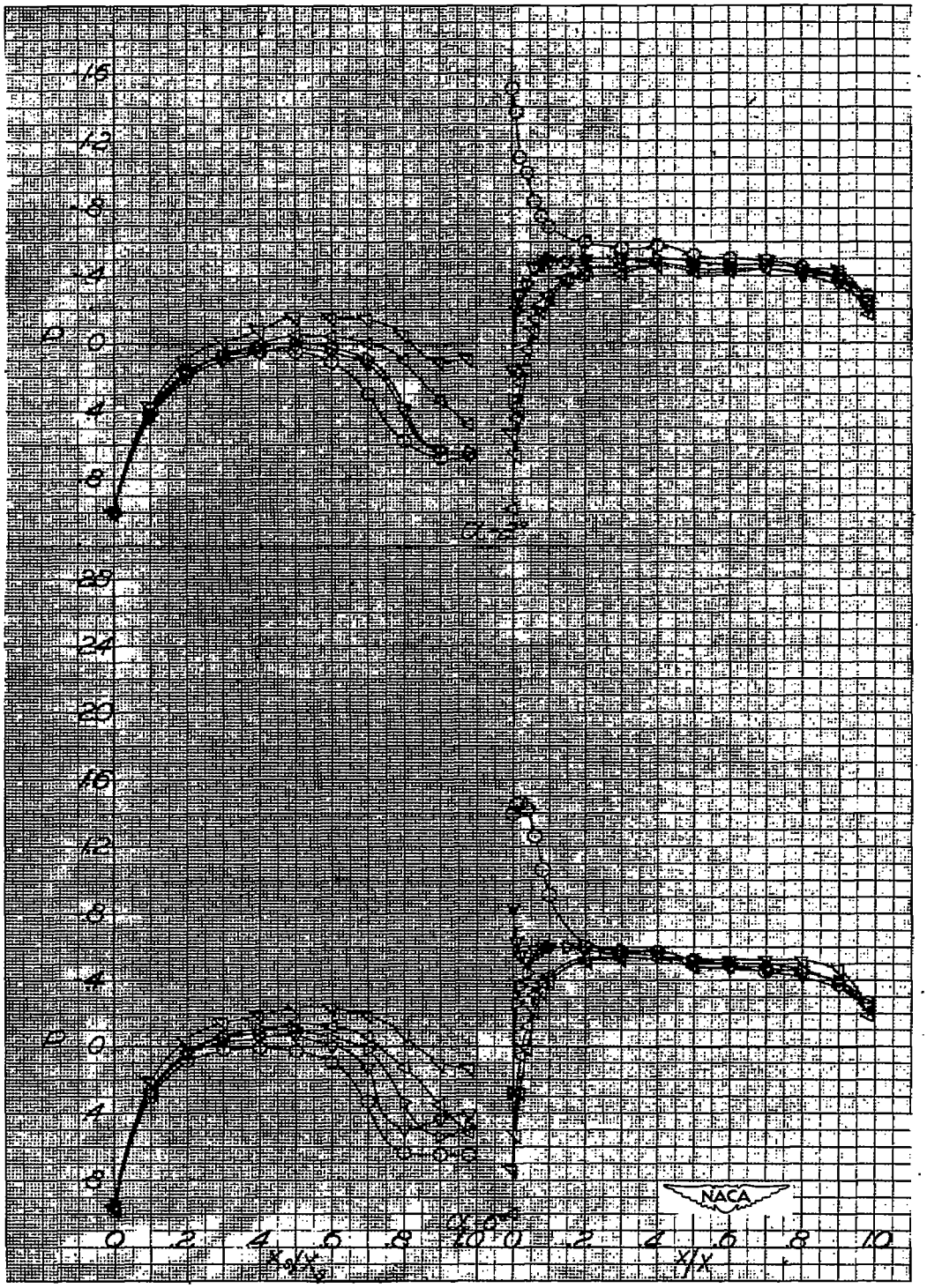
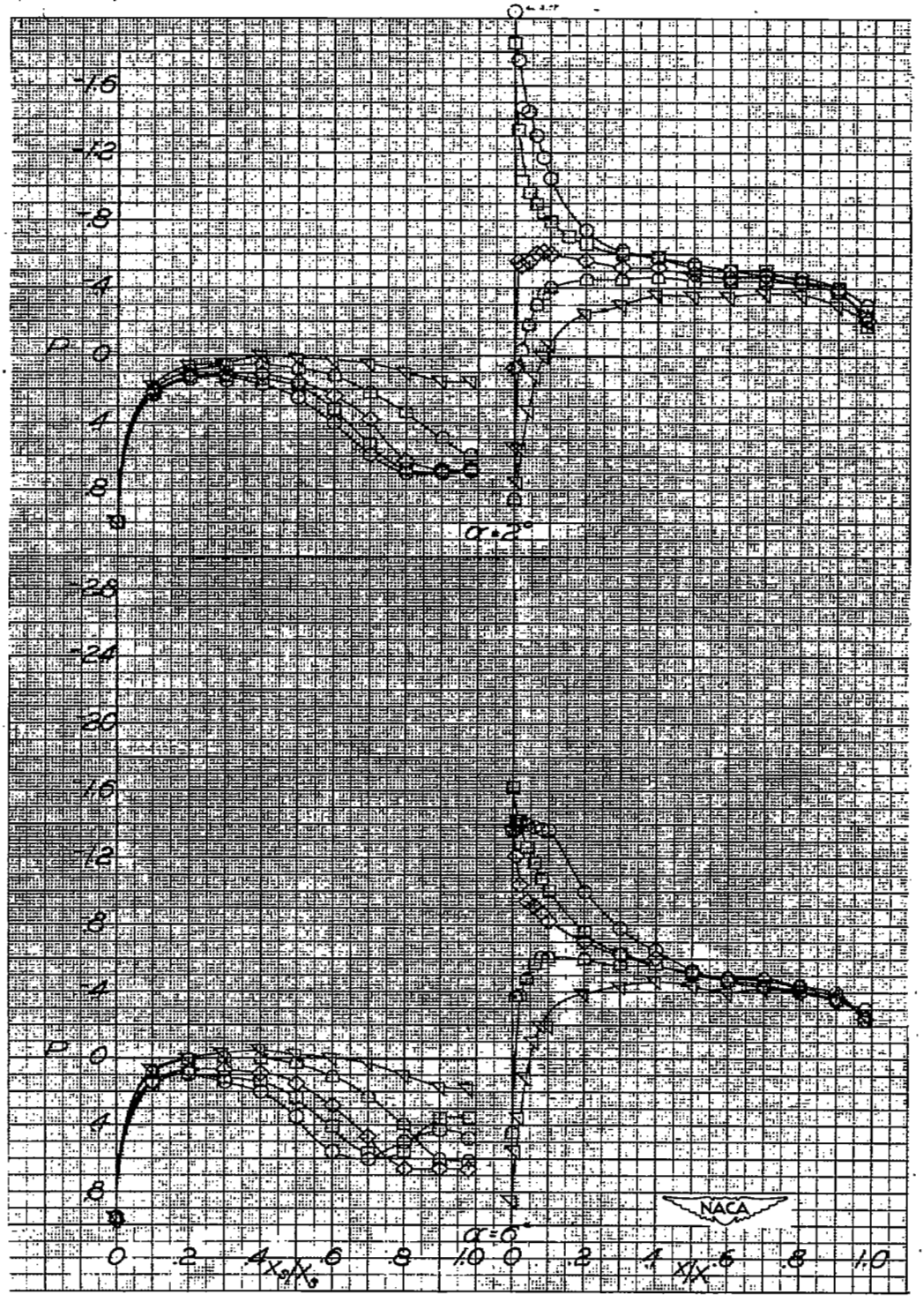


Figure 54.- Concluded.

Figure 55.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-40-080 spinner.



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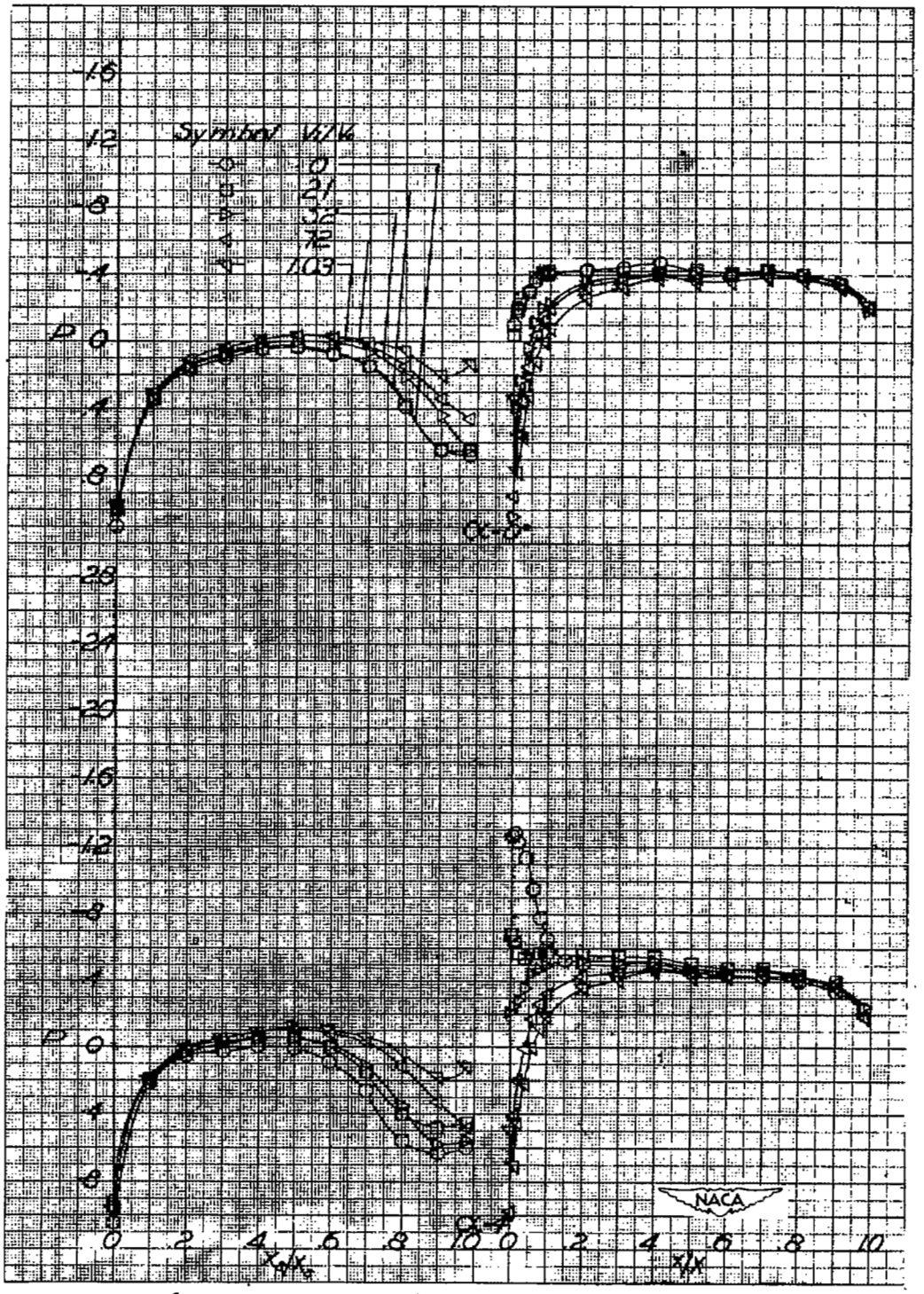


Figure 56.- Static-pressure distributions on top of NACA 1-70-050 cowling with NACA 1-60-080 spinner.

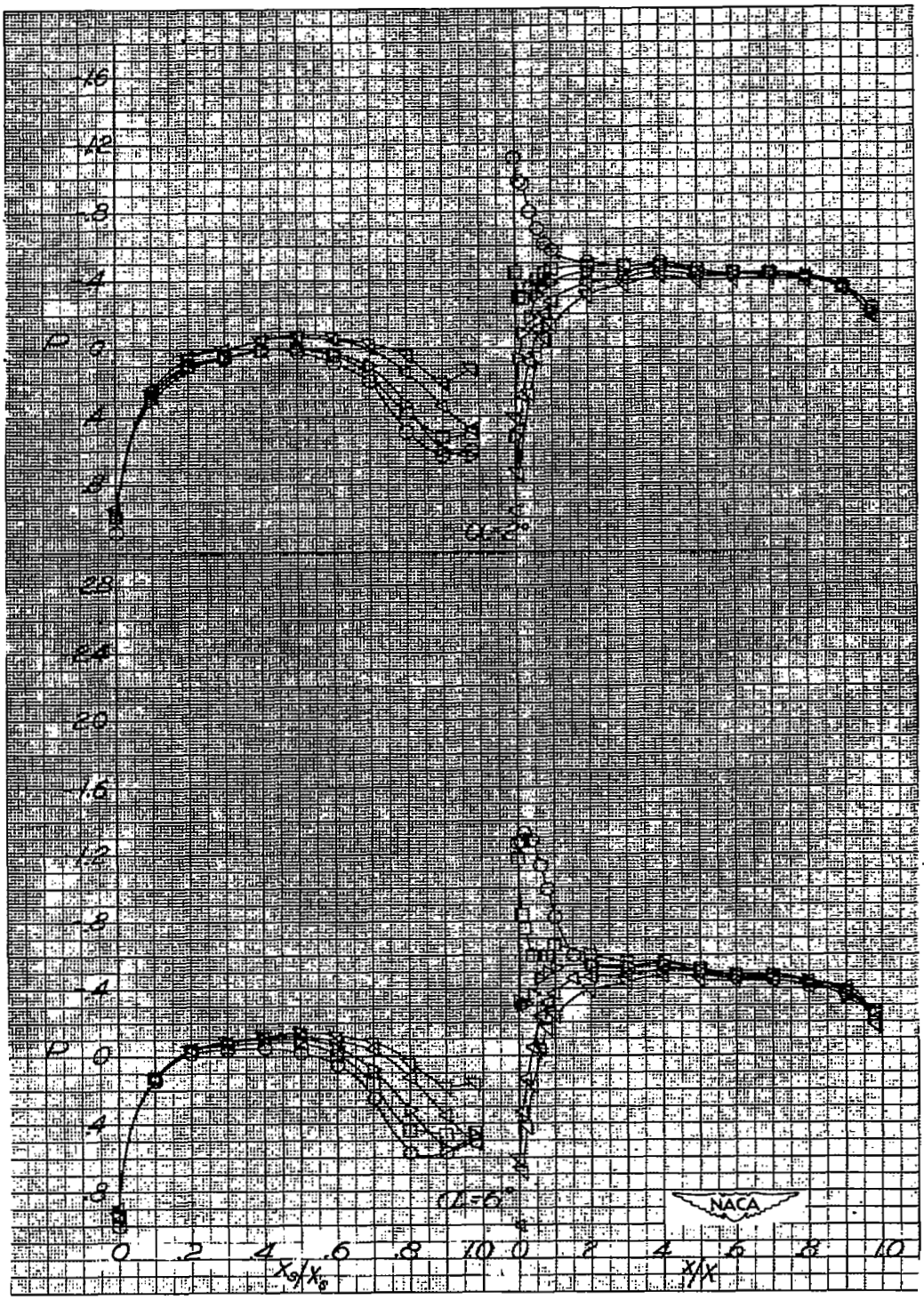


Figure 56.- Concluded.

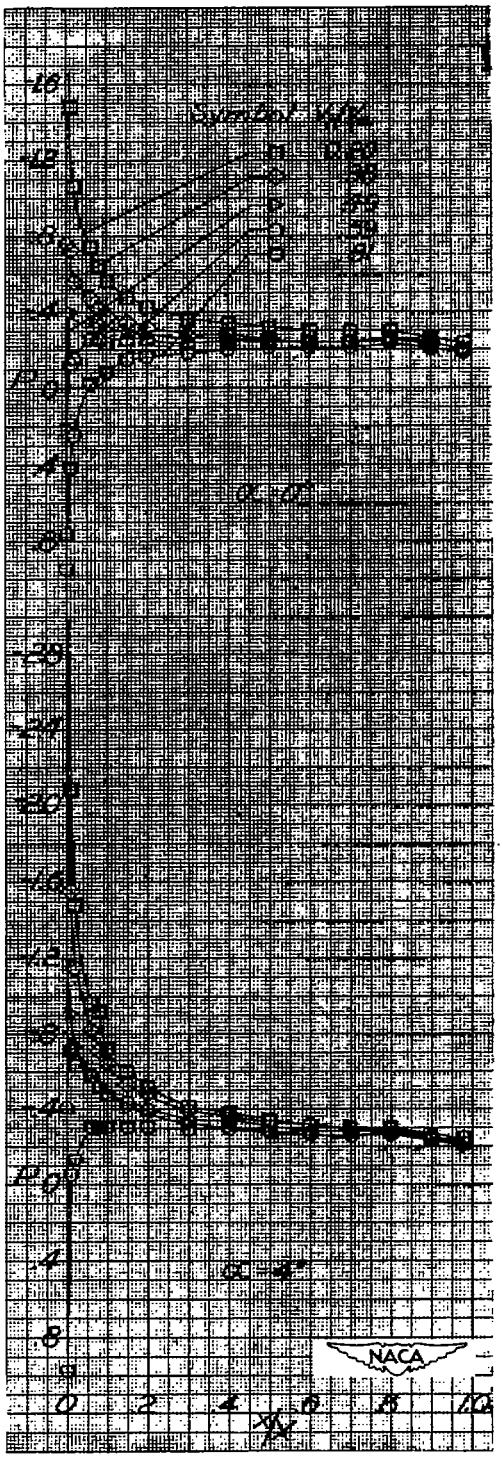
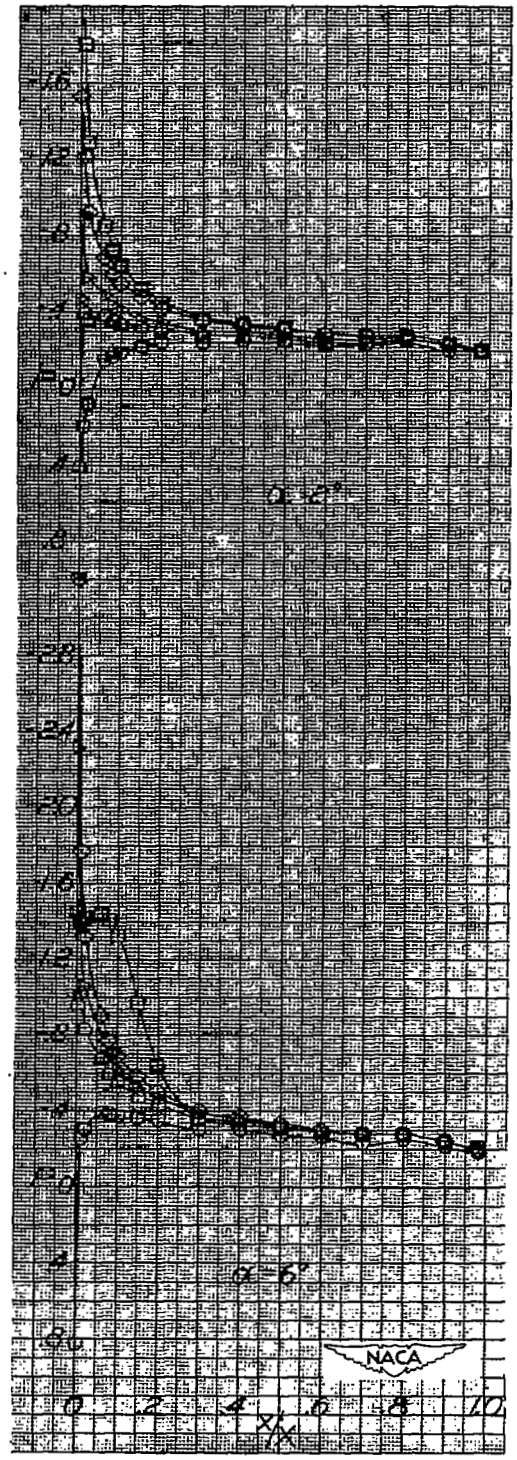


Figure 57.- Static-pressure distributions on top of NACA 1-70-075 open-nose cowling.



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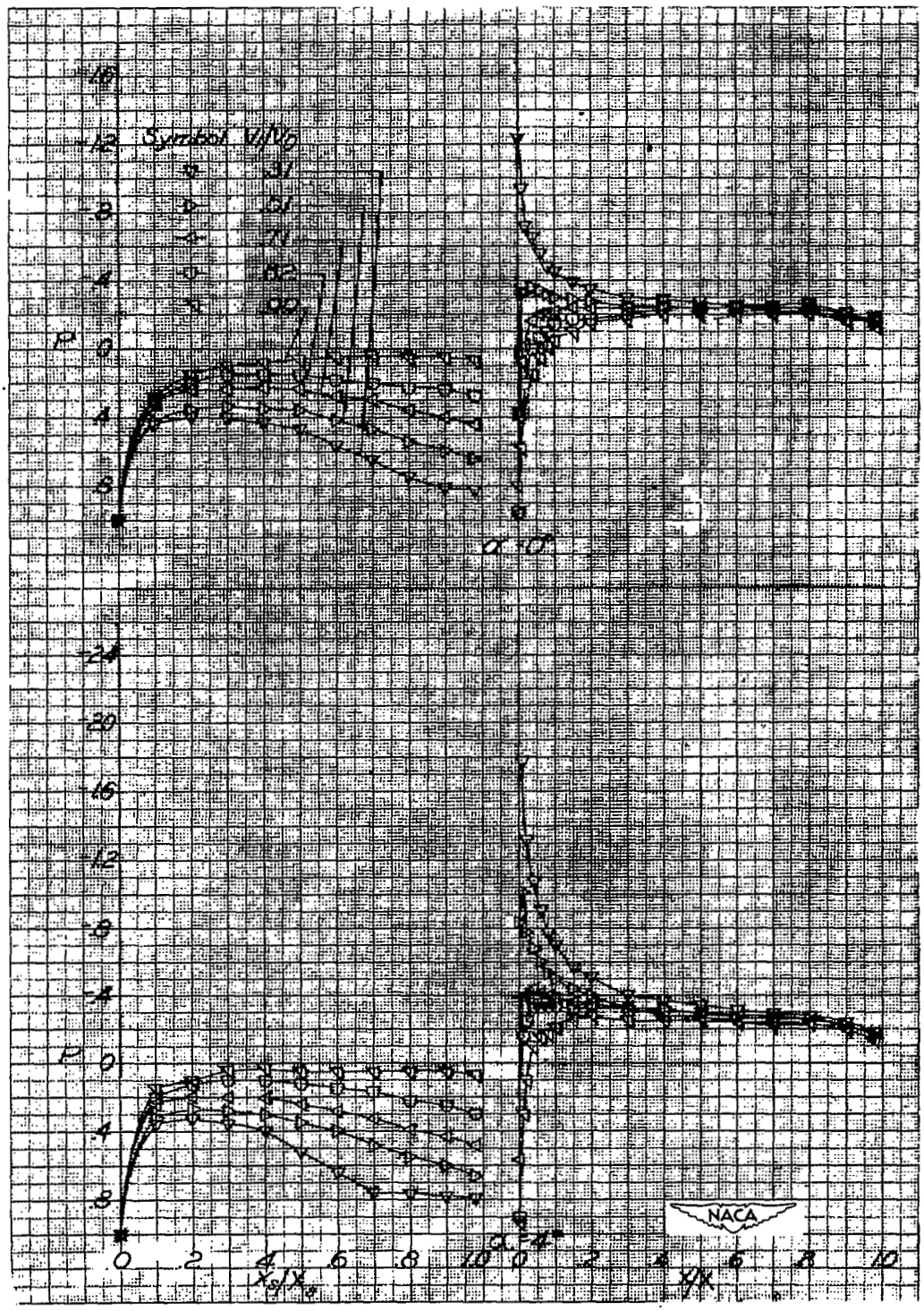
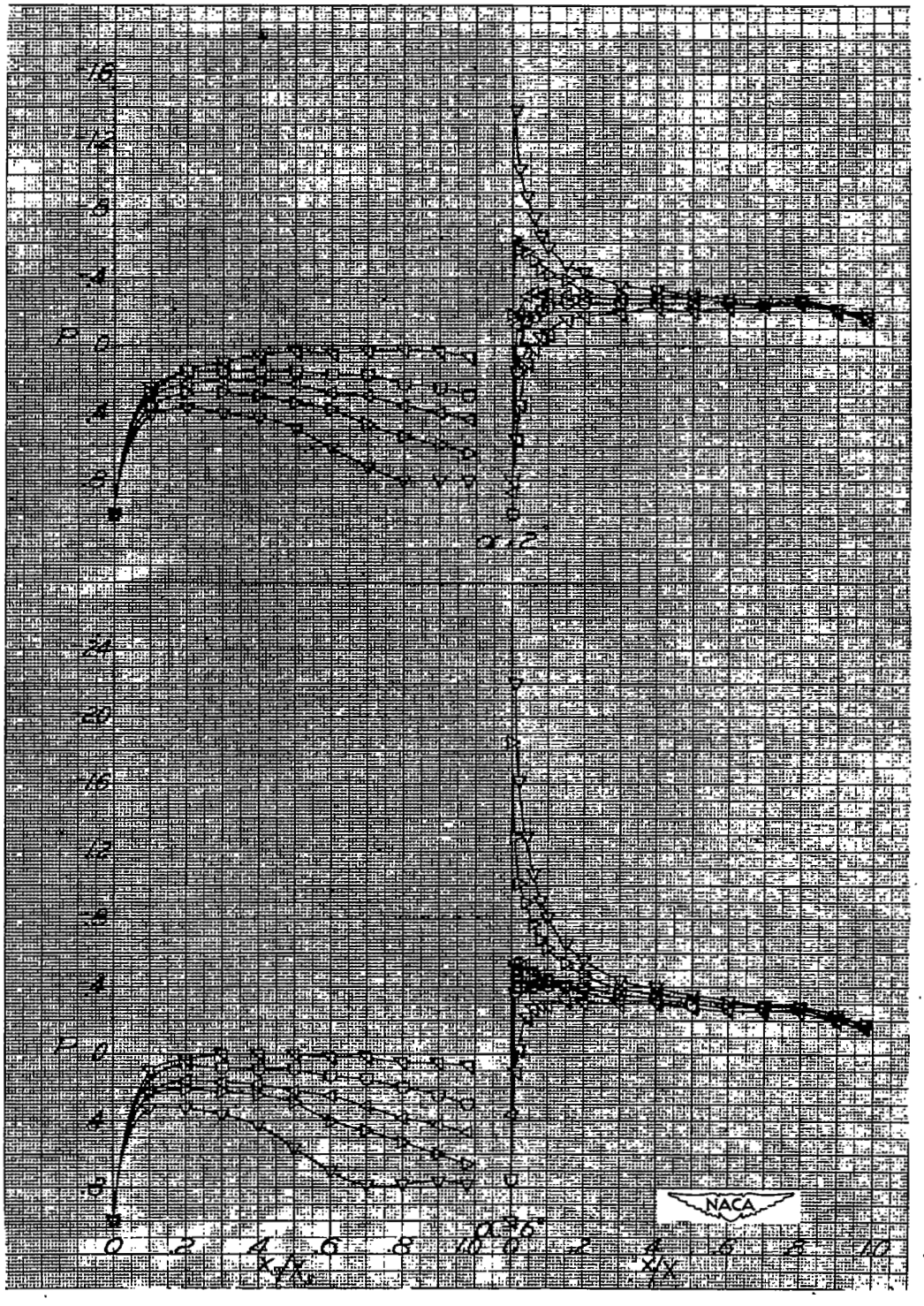


Figure 58.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-20-040 spinner.



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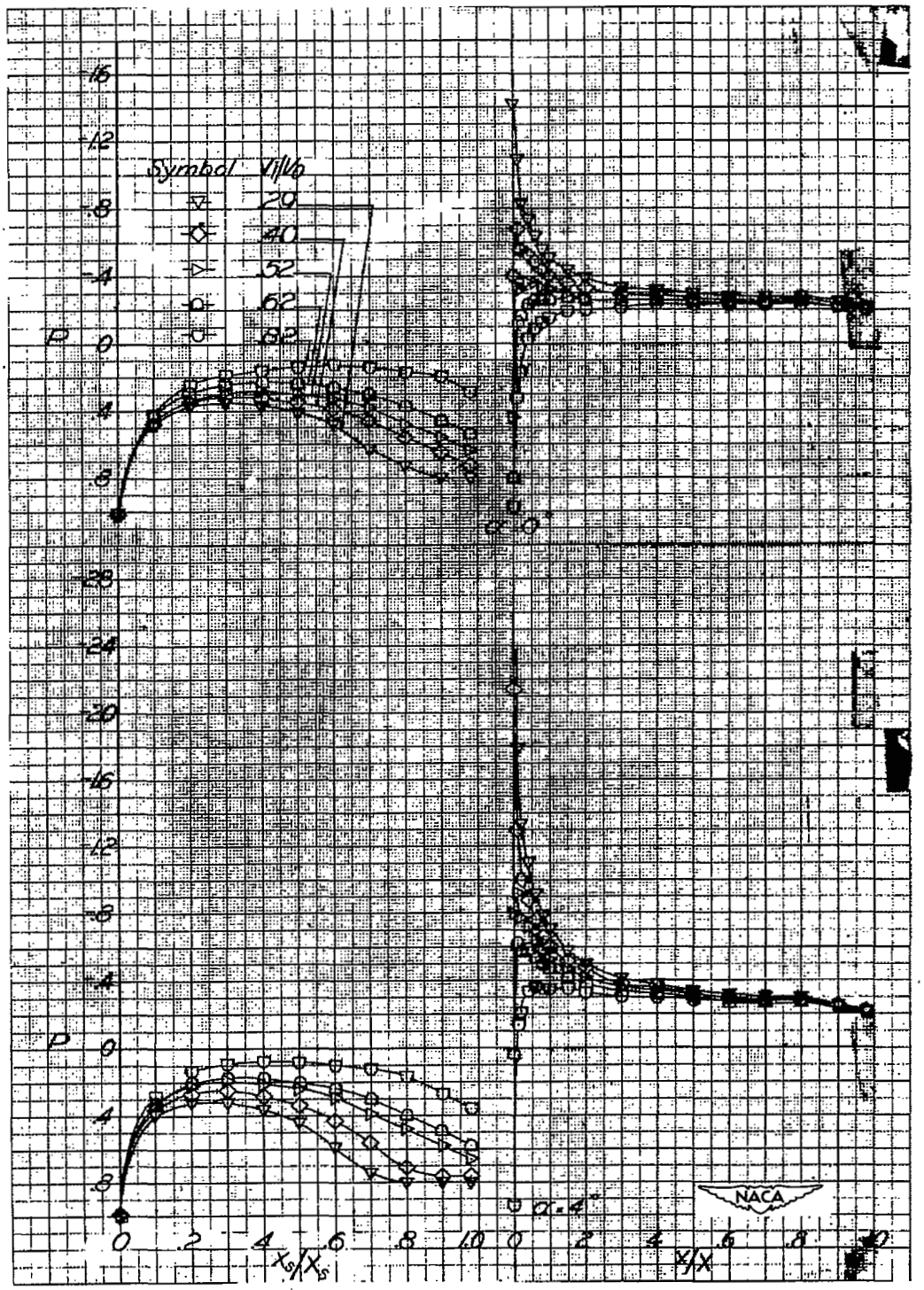


Figure 59.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-30-040 spinner.

Figure 59.- Concluded.

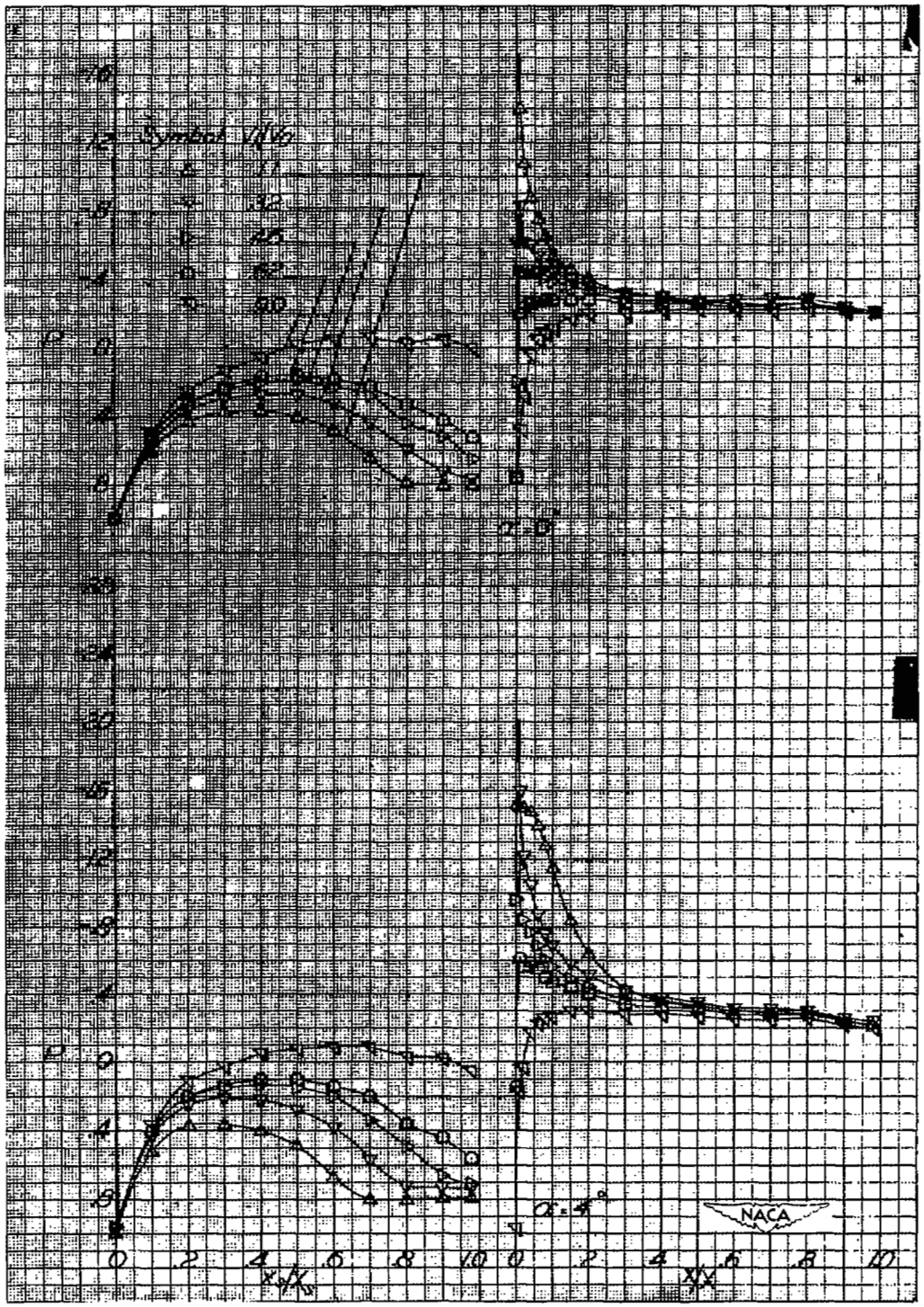


Figure 60.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-40-040 spinner.

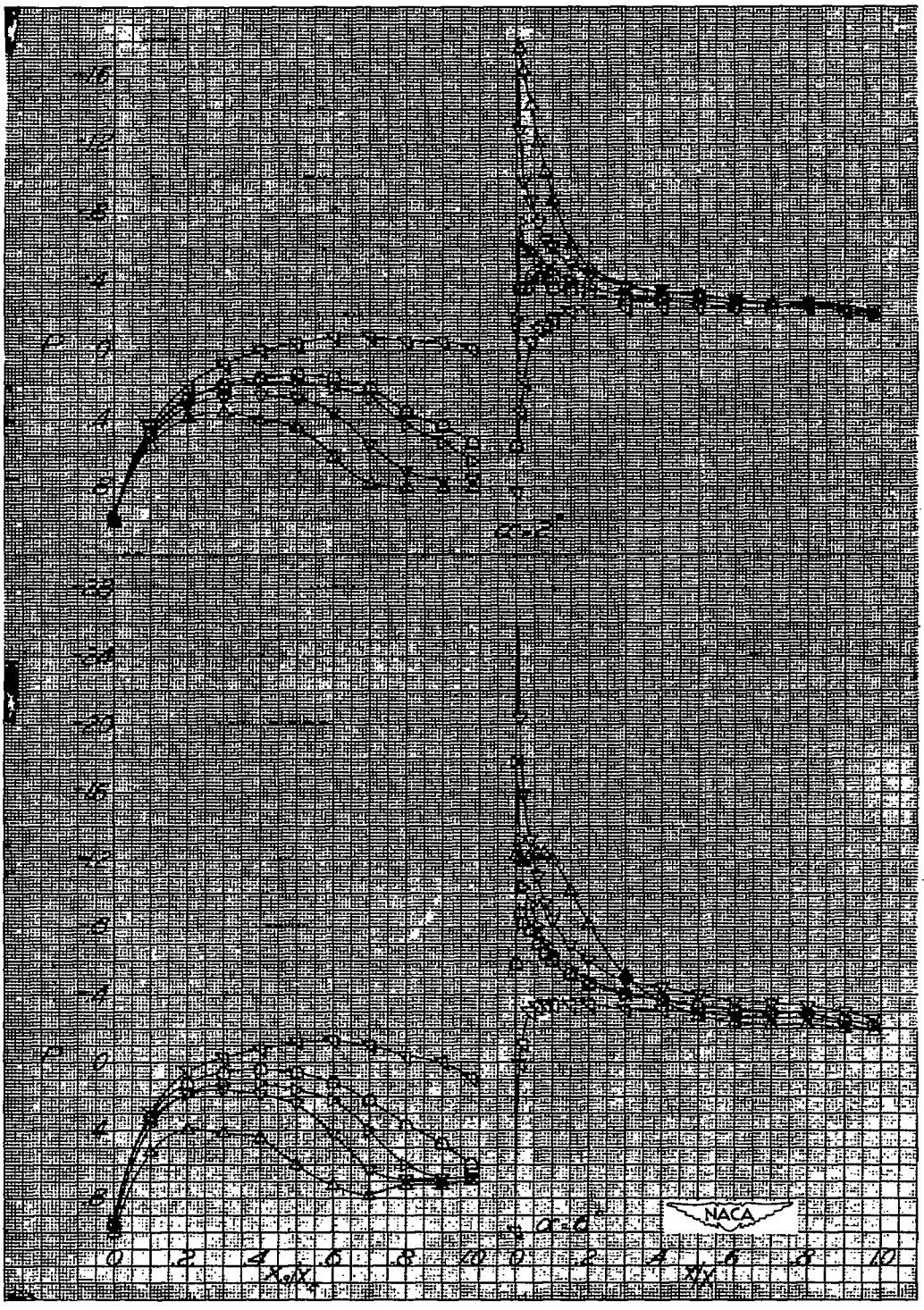


Figure 60.- Concluded.

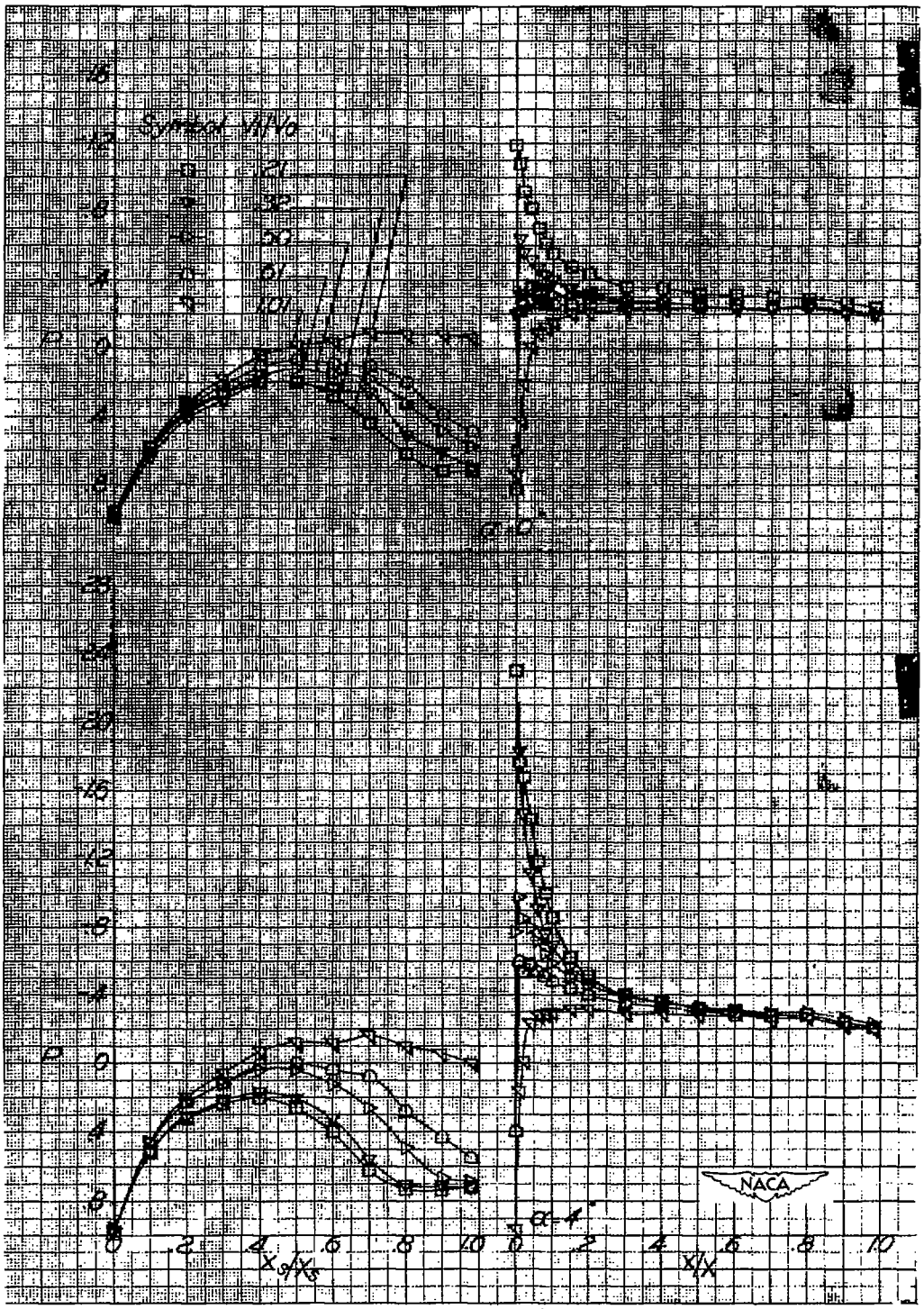
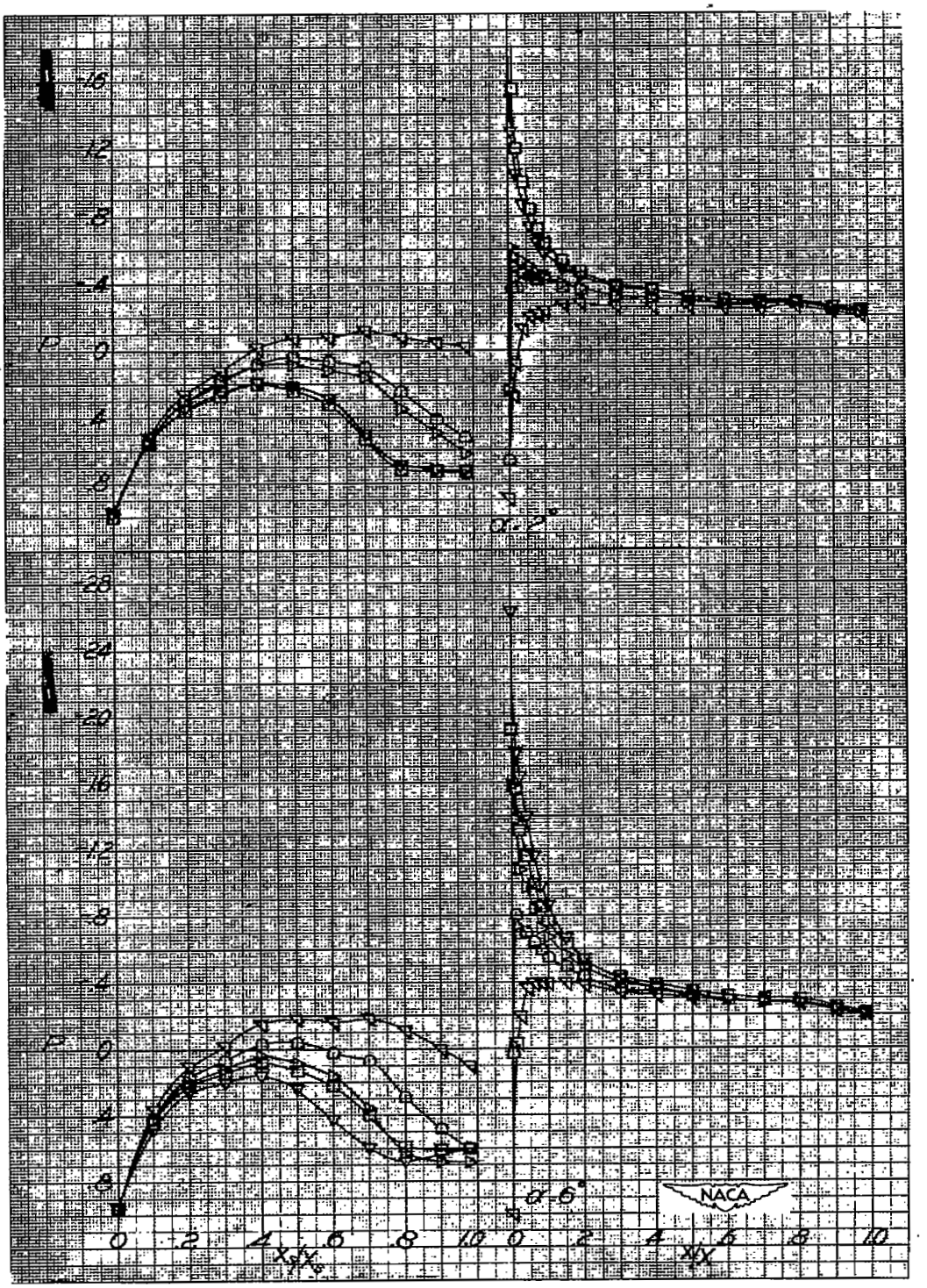


Figure 61.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-50-040 spinner.



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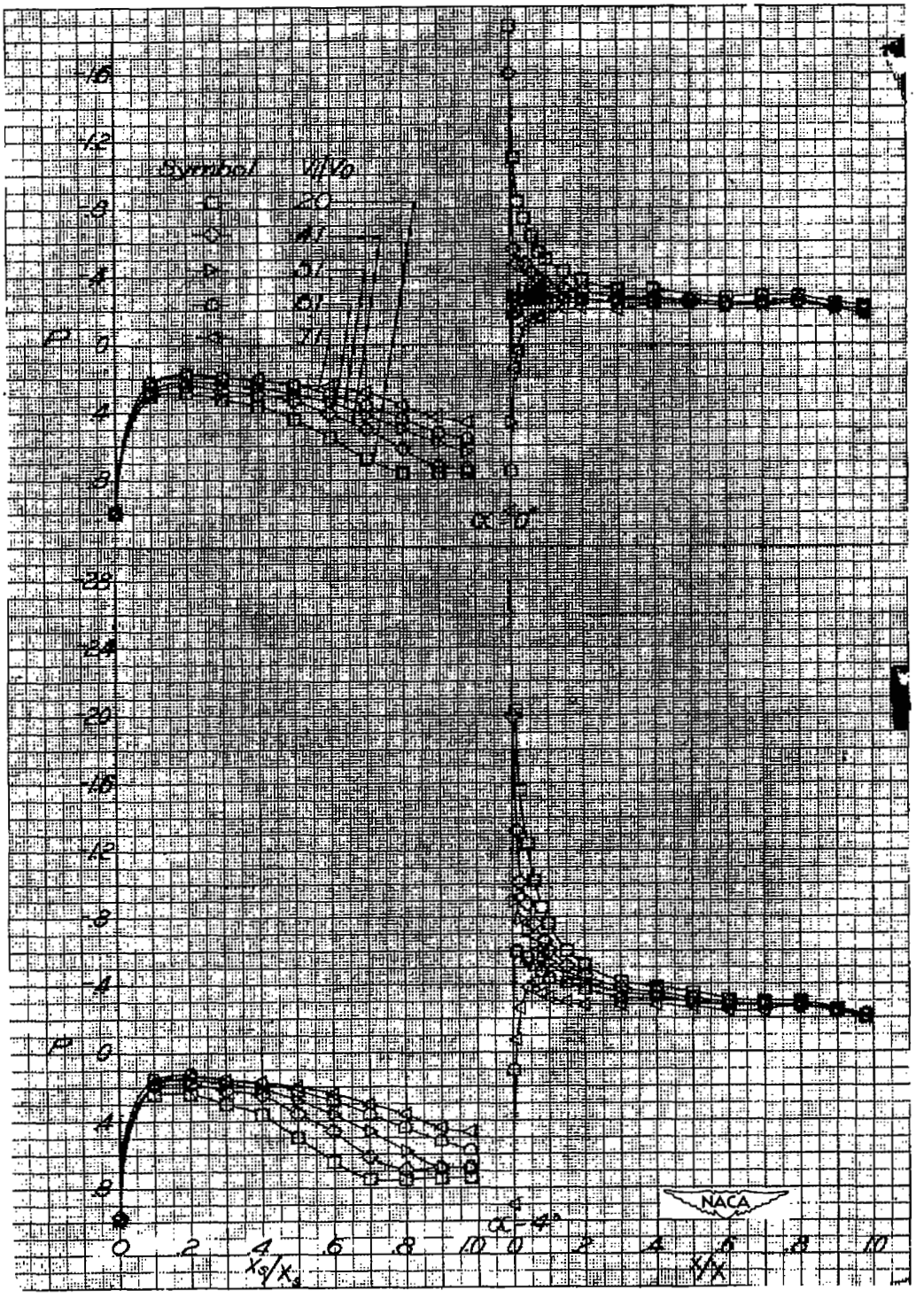
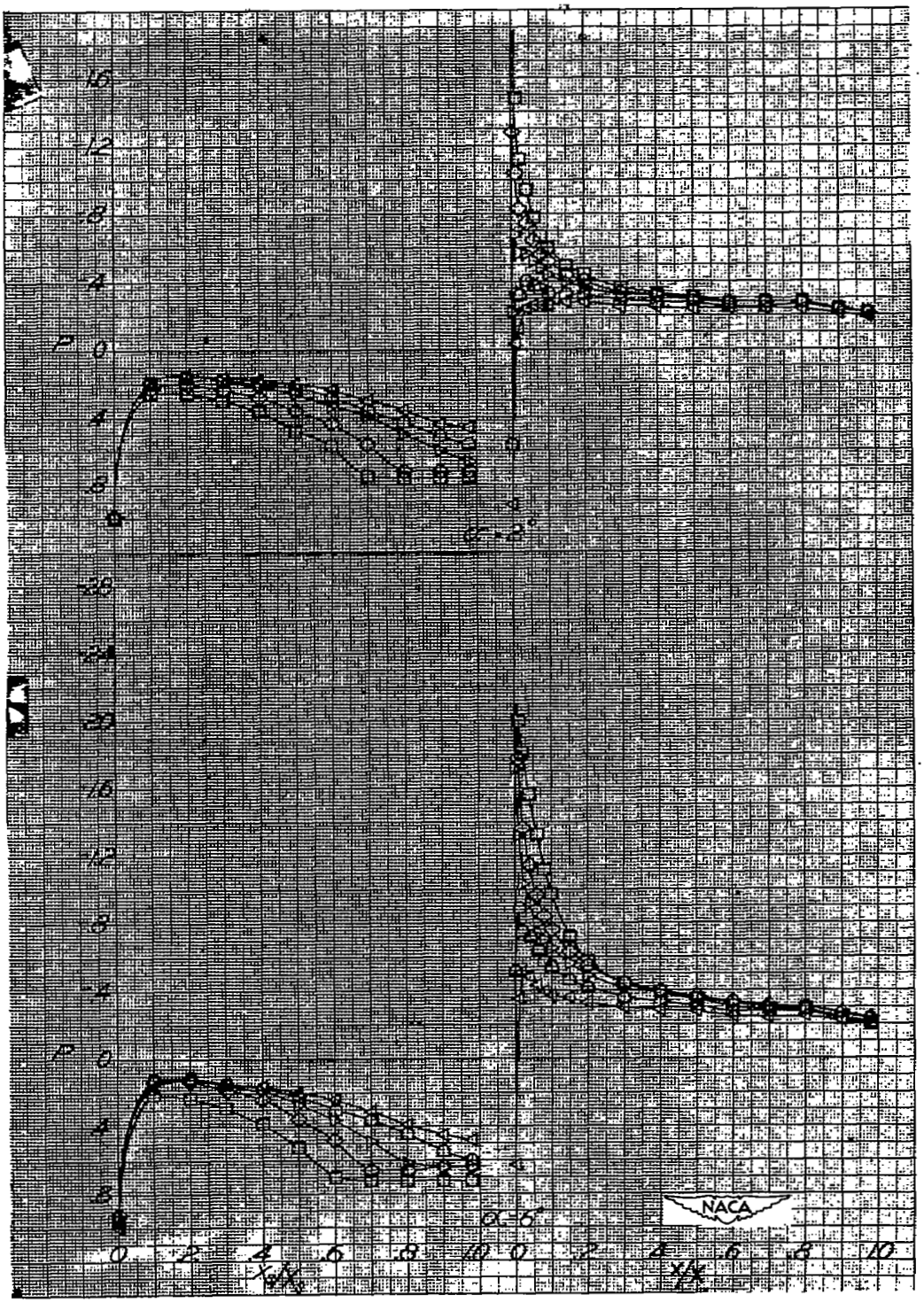


Figure 62.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-20-060 spinner.



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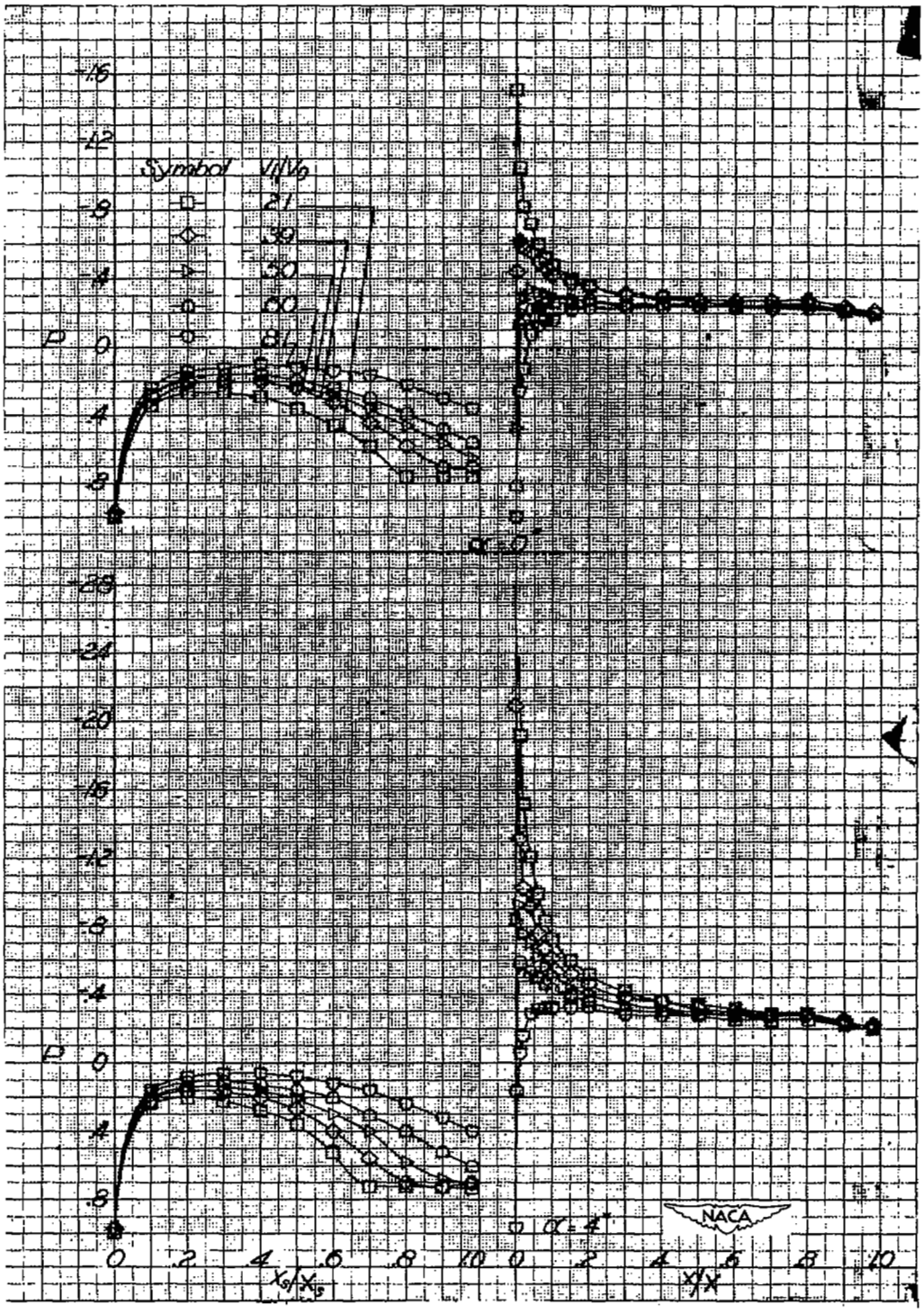


Figure 63.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-30-060 spinner.

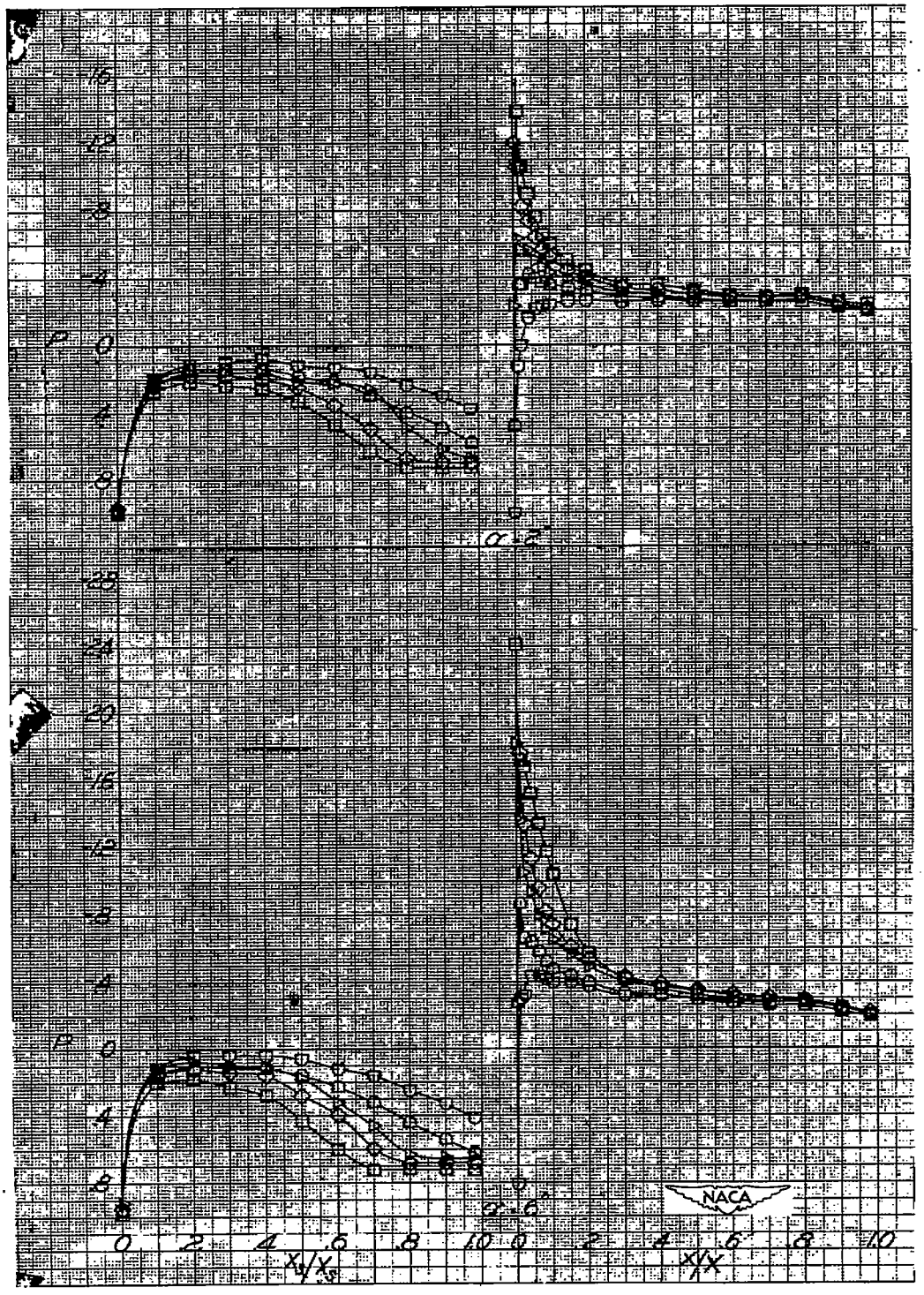


Figure 63.- Concluded.

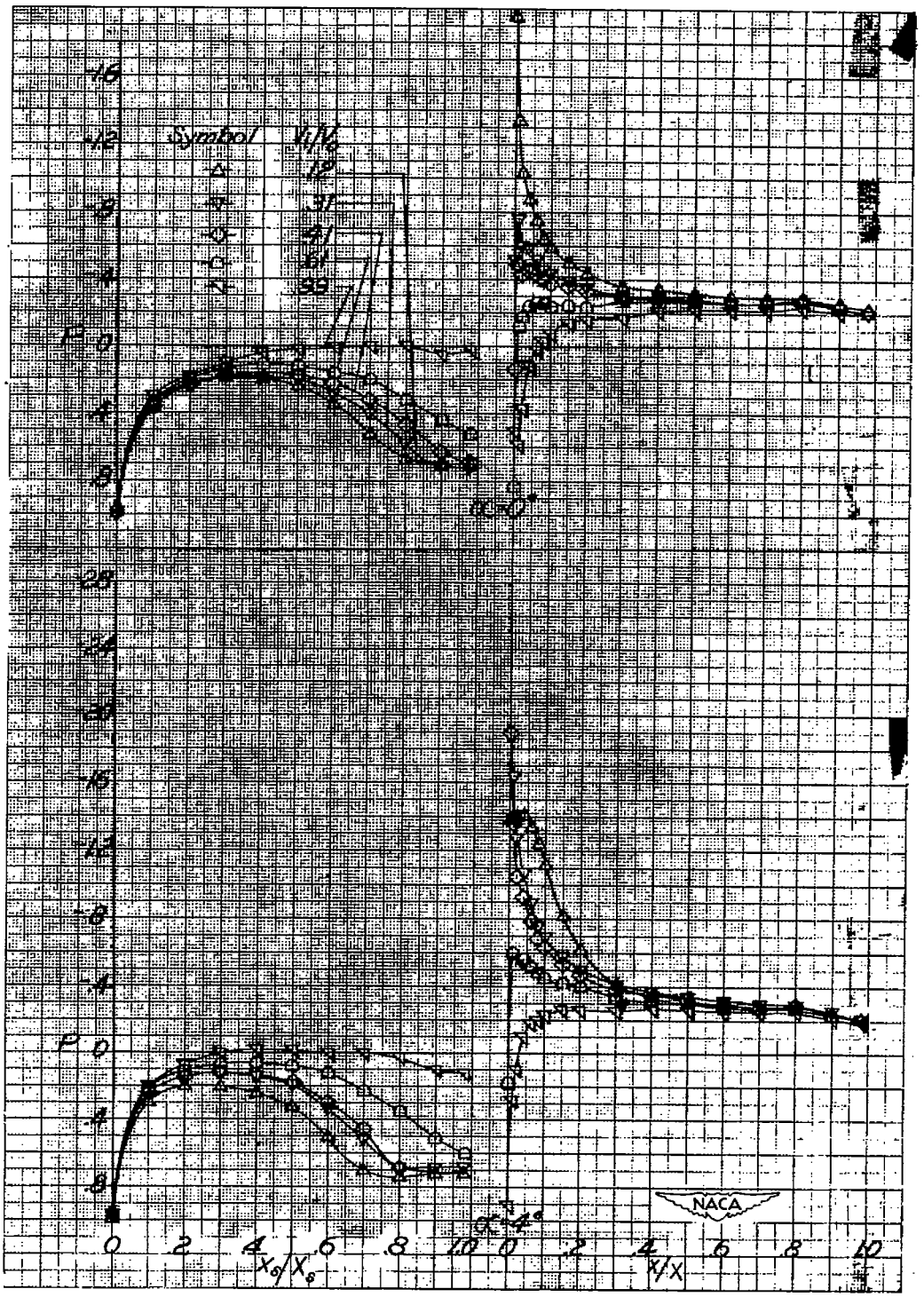


Figure 64.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-40-060 spinner.

Figure 64.- Concluded.

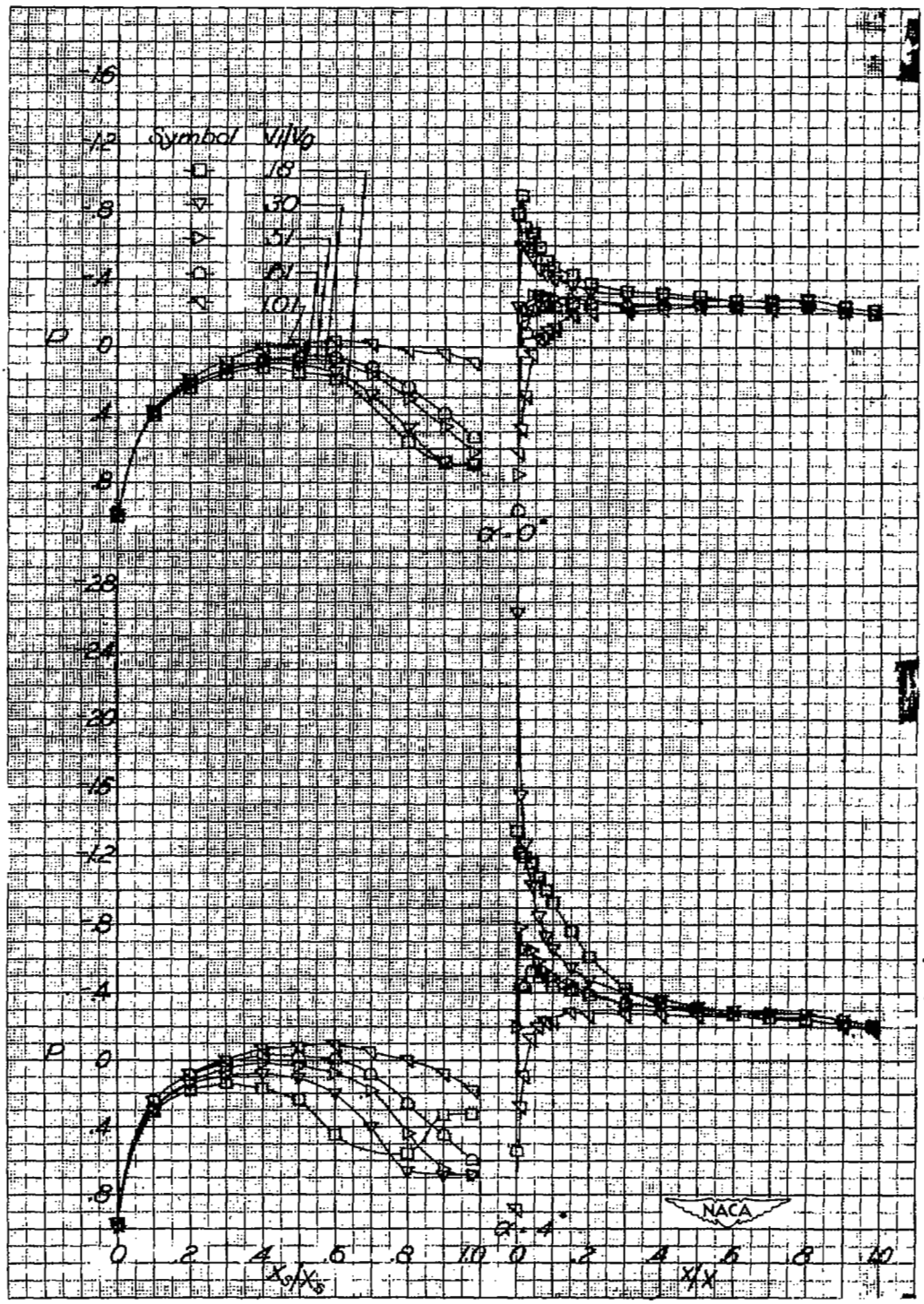
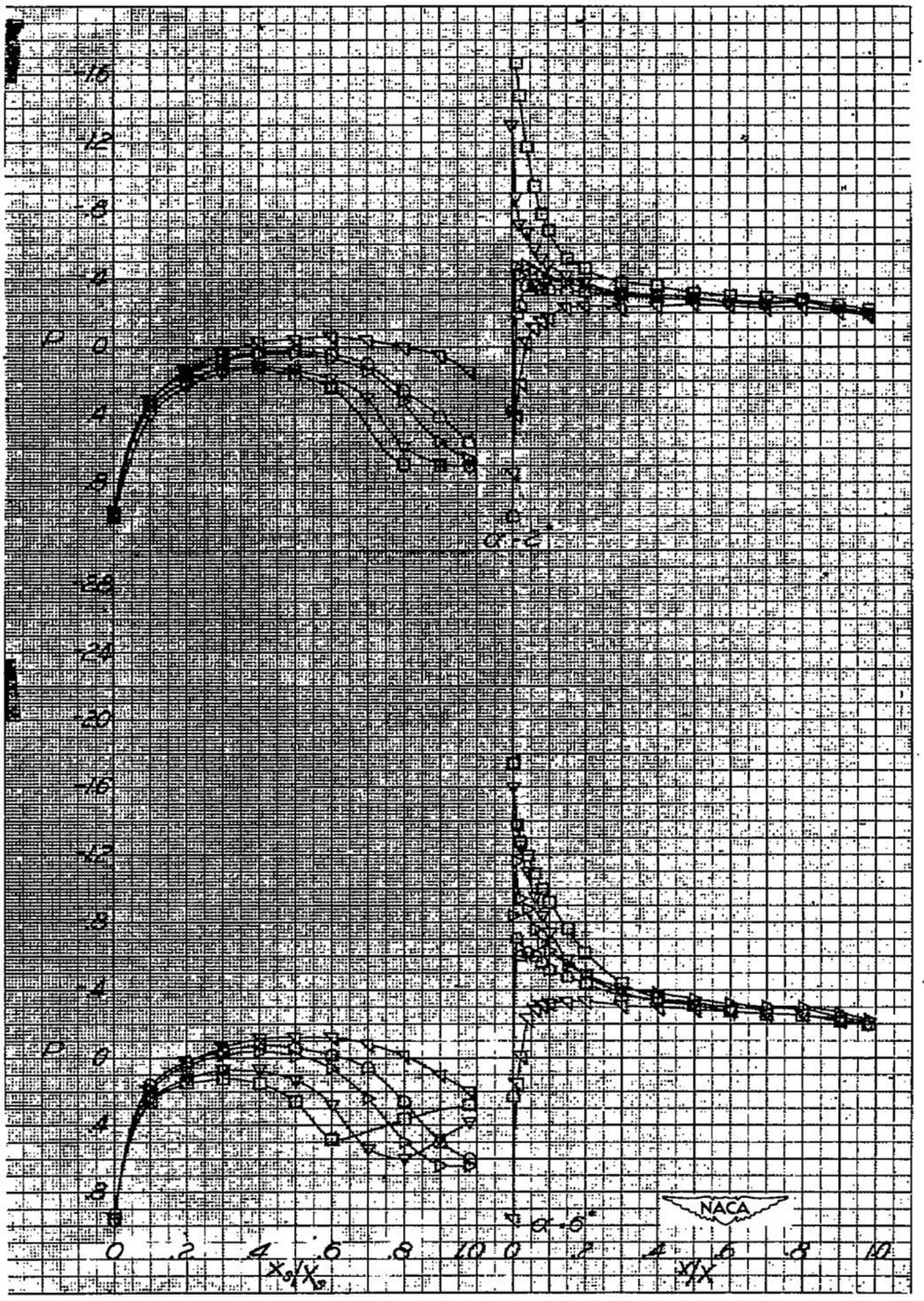


Figure 65.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-50-060 spinner.



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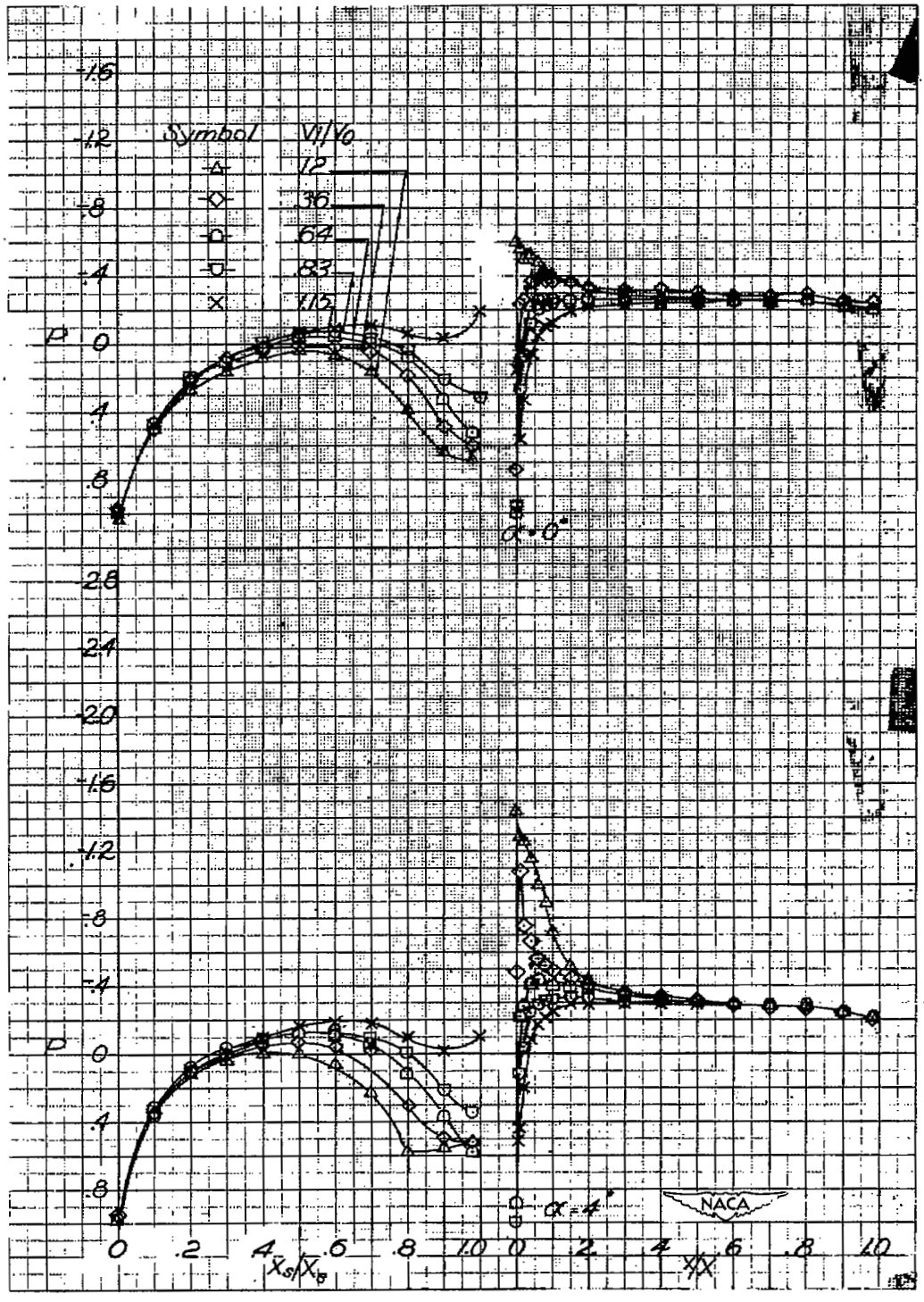


Figure 66.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-60-060 spinner.

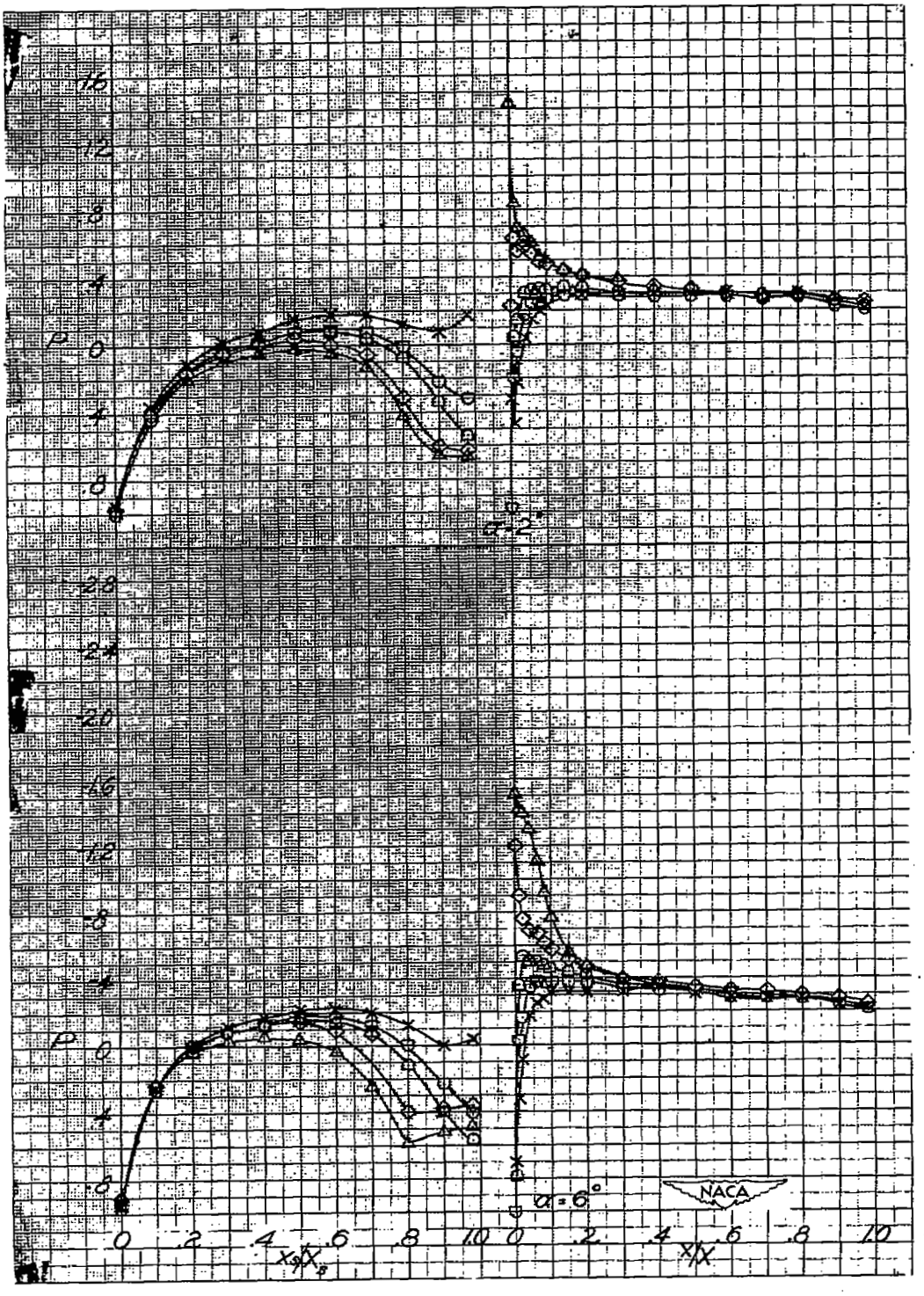


Figure 66.- Concluded.

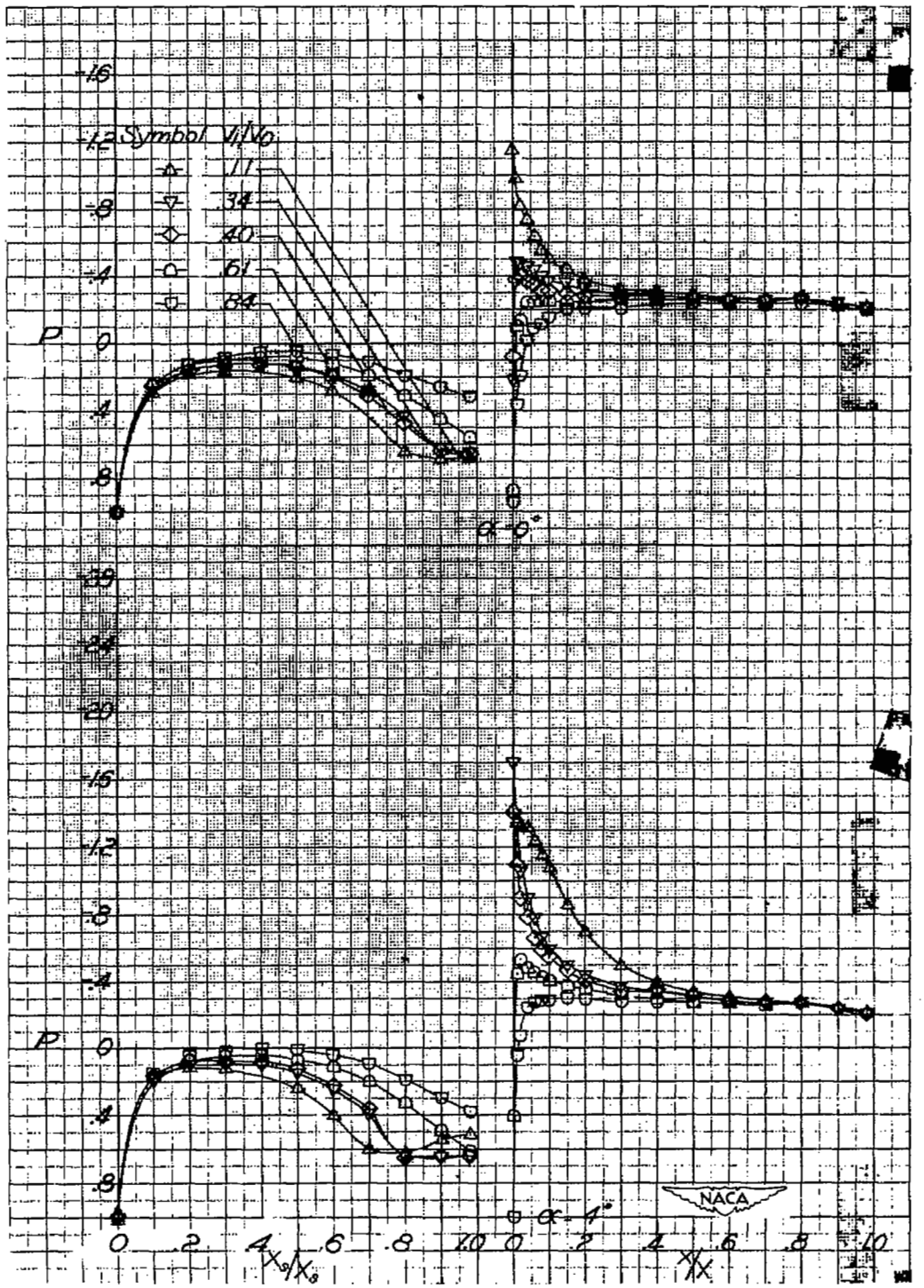


Figure 67.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-40-080 spinner.

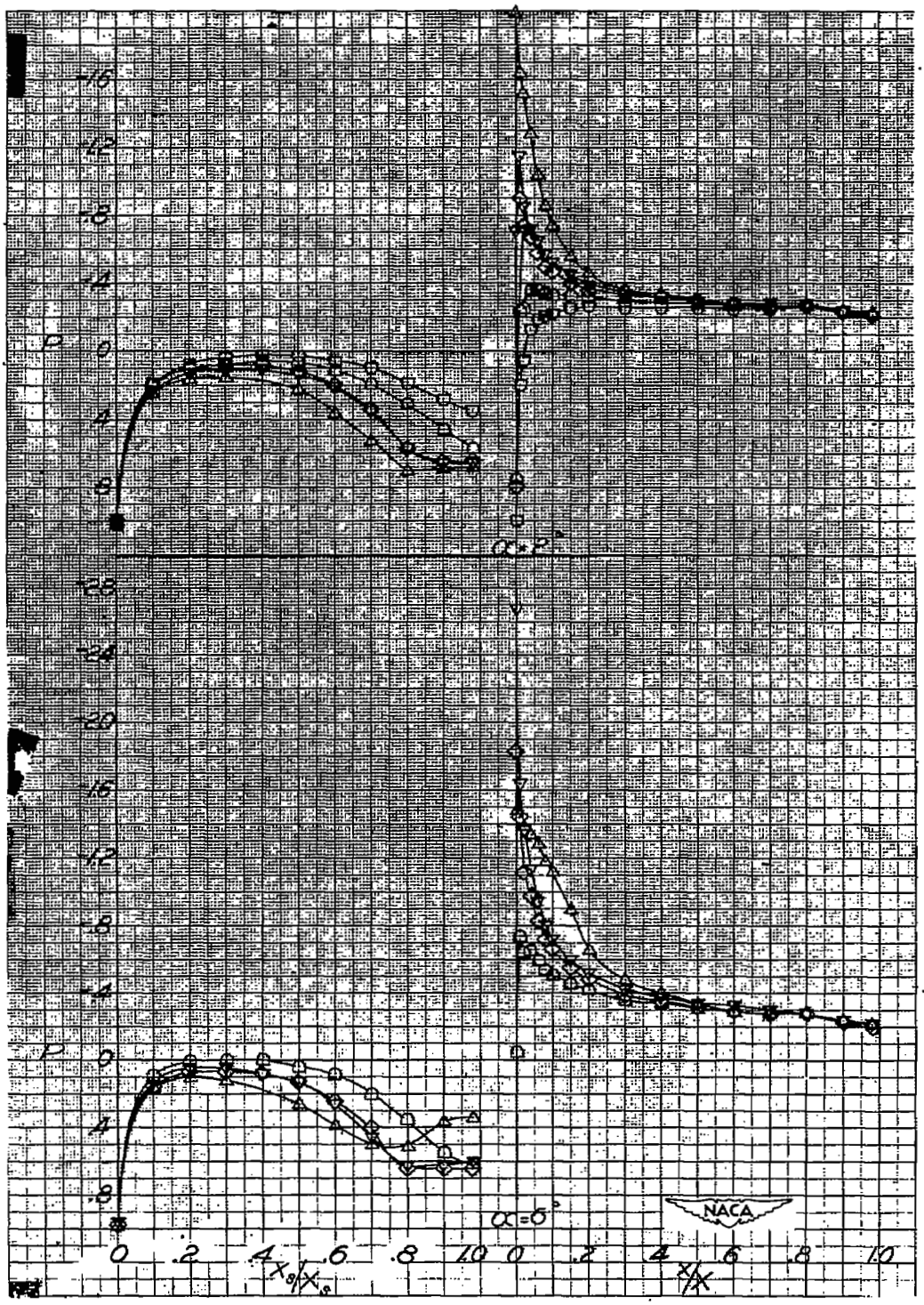


Figure 67.- Concluded.

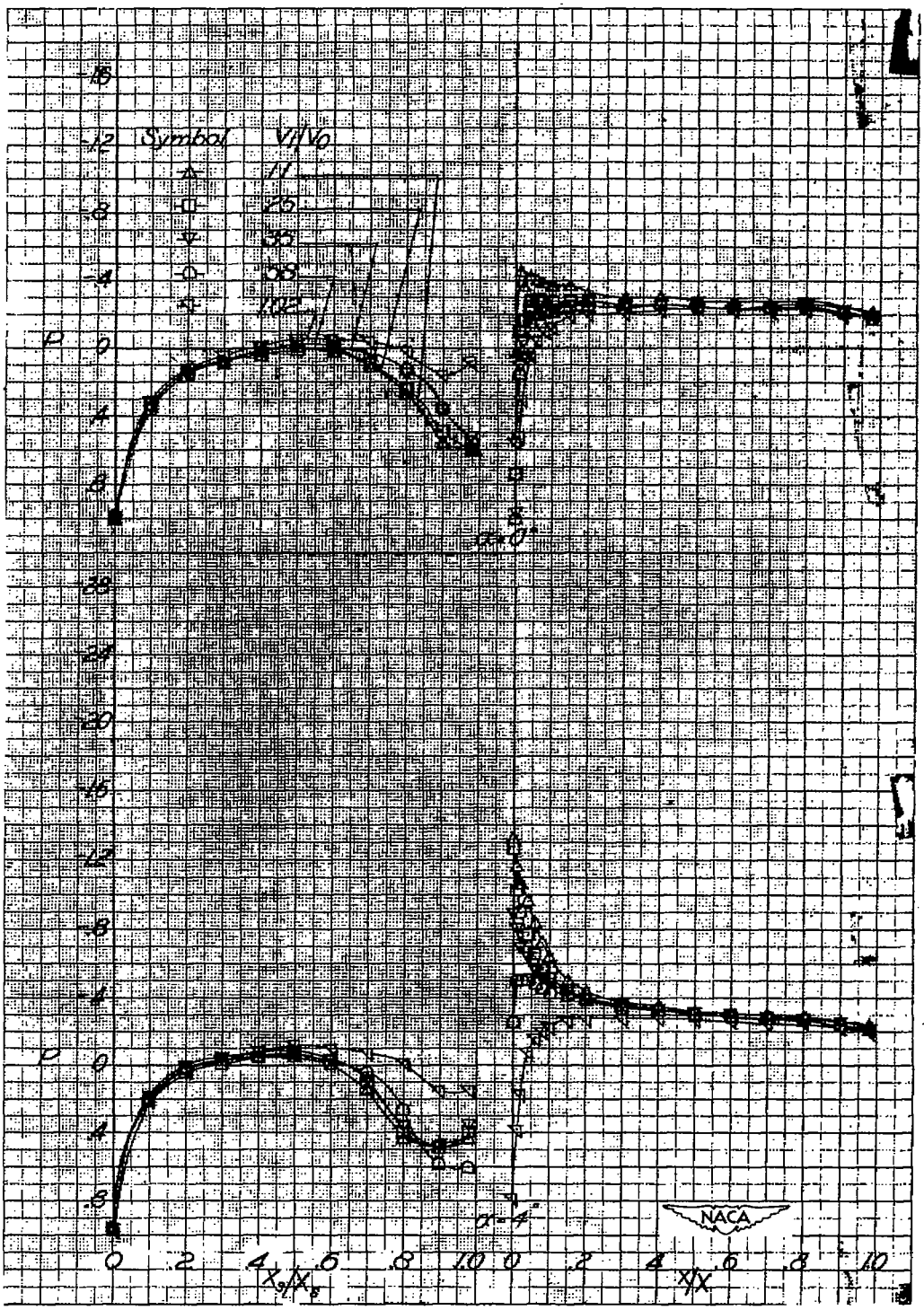


Figure 68.- Static-pressure distributions on top of NACA 1-70-075 cowling with NACA 1-60-080 spinner.

Figure 68.- Concluded.

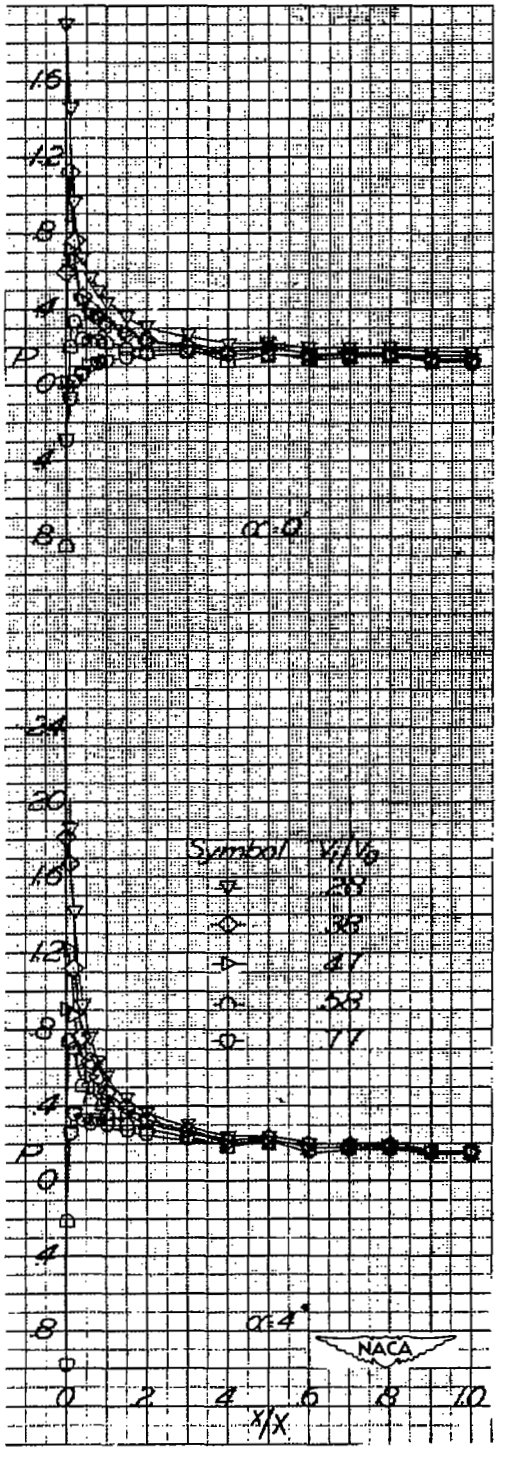


Figure 69.- Static-pressure distributions on top of NACA 1-70-100 open-nose cowling.

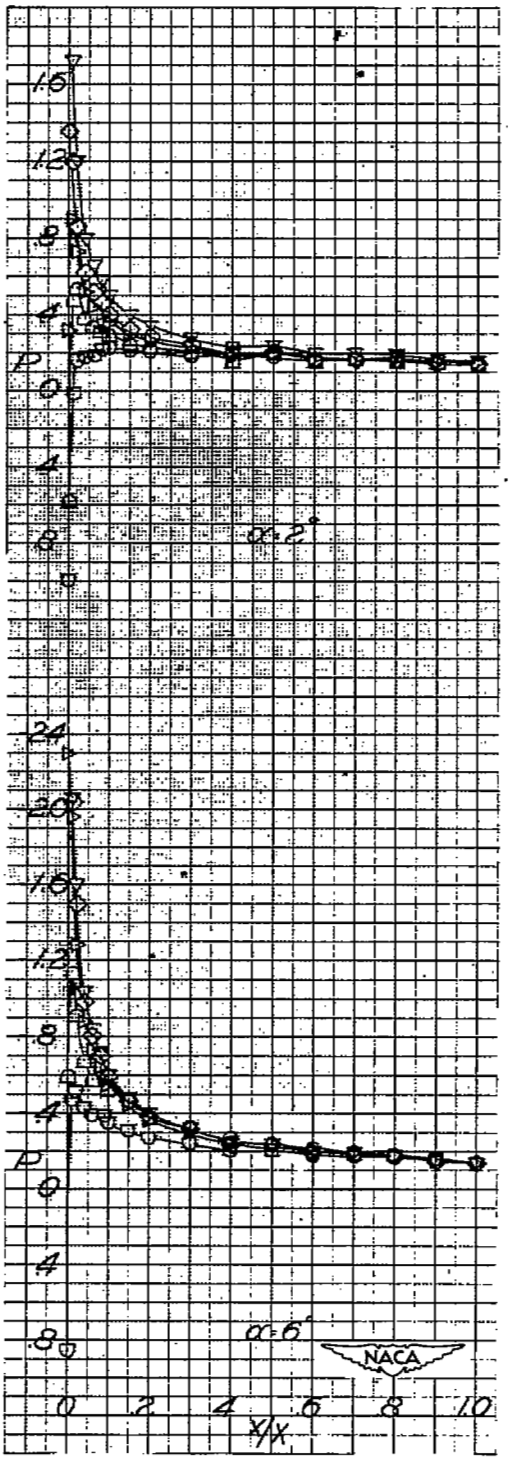


Figure 69.- Concluded.

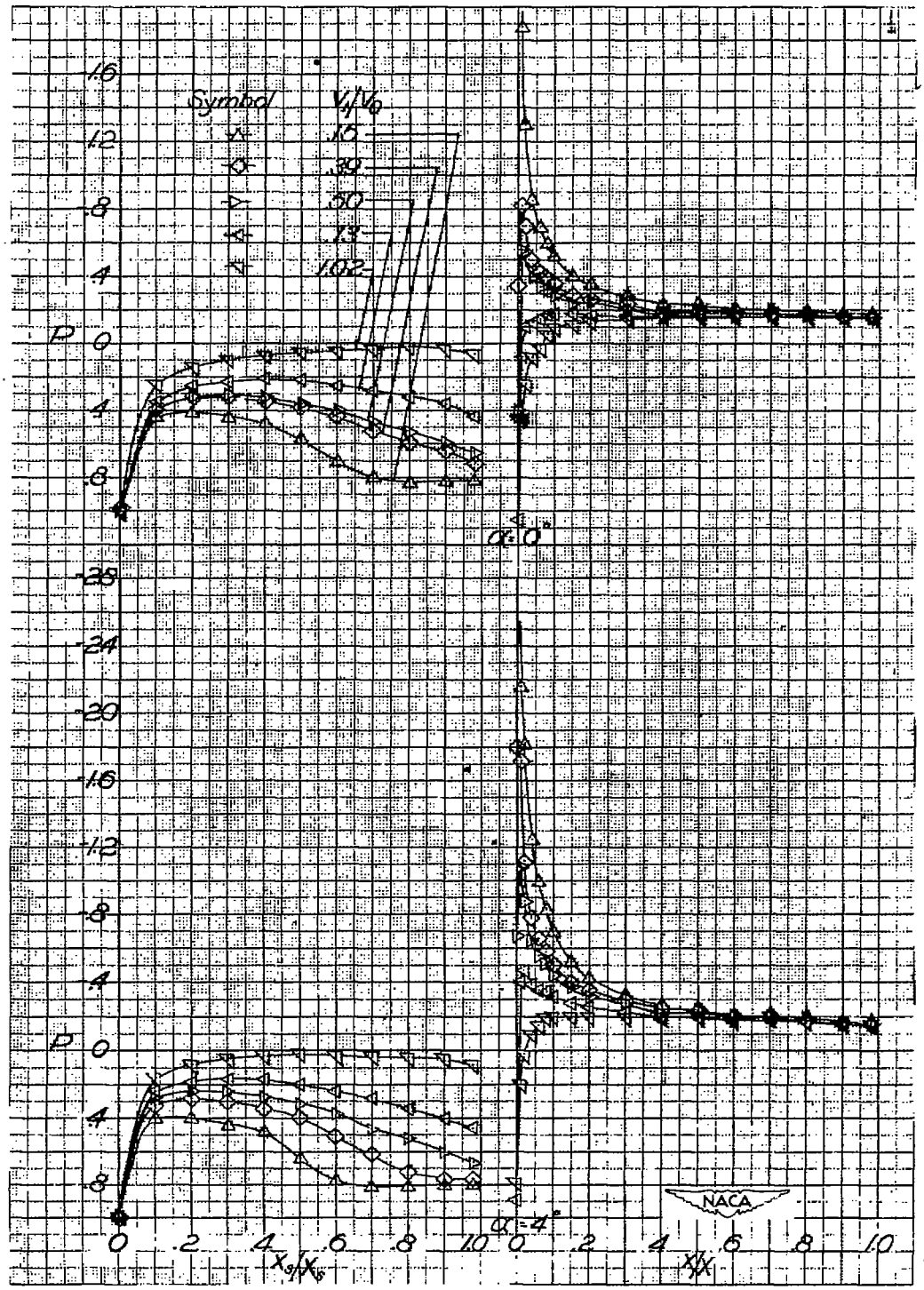
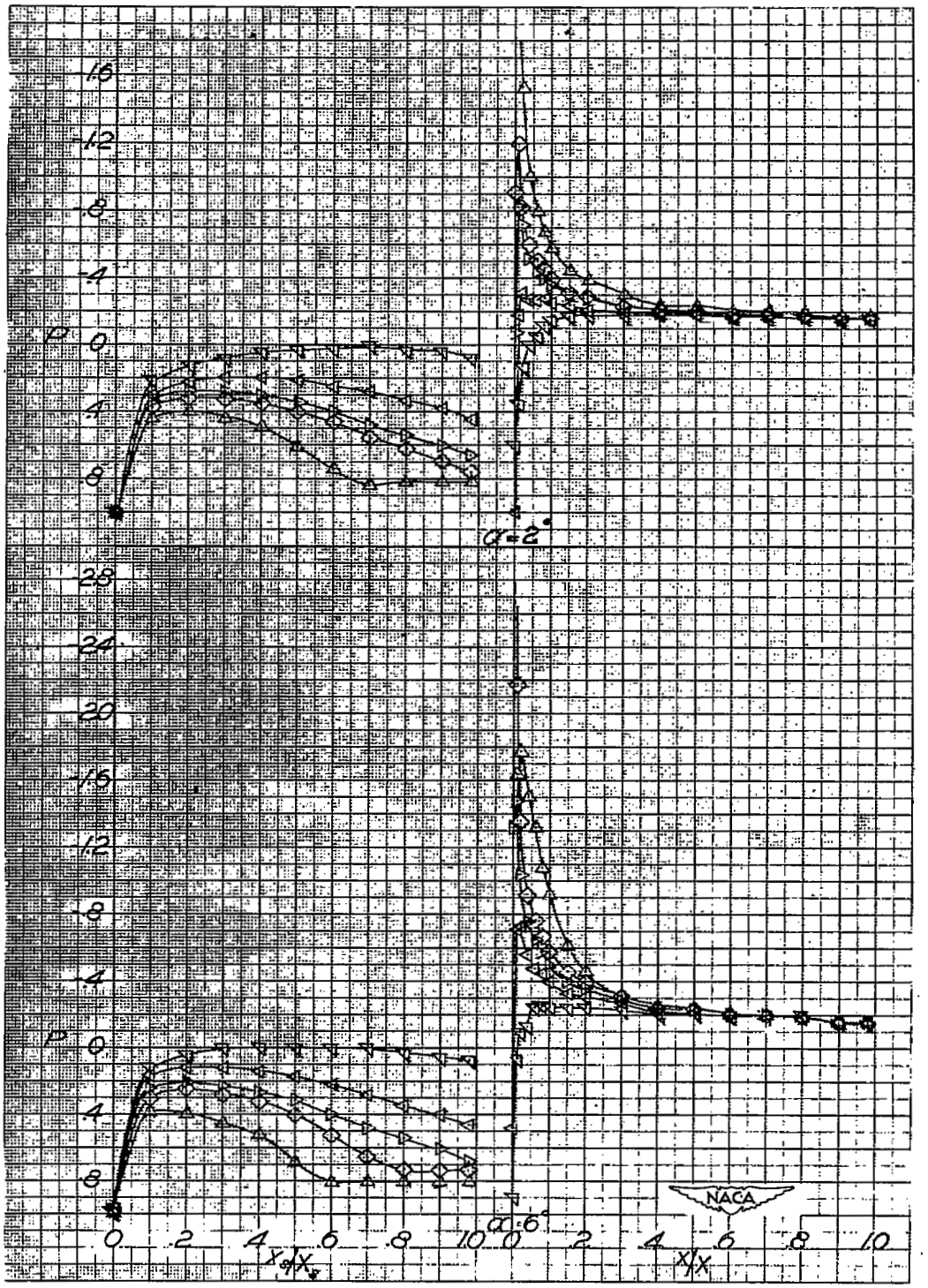


Figure 70.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-20-040 spinner.



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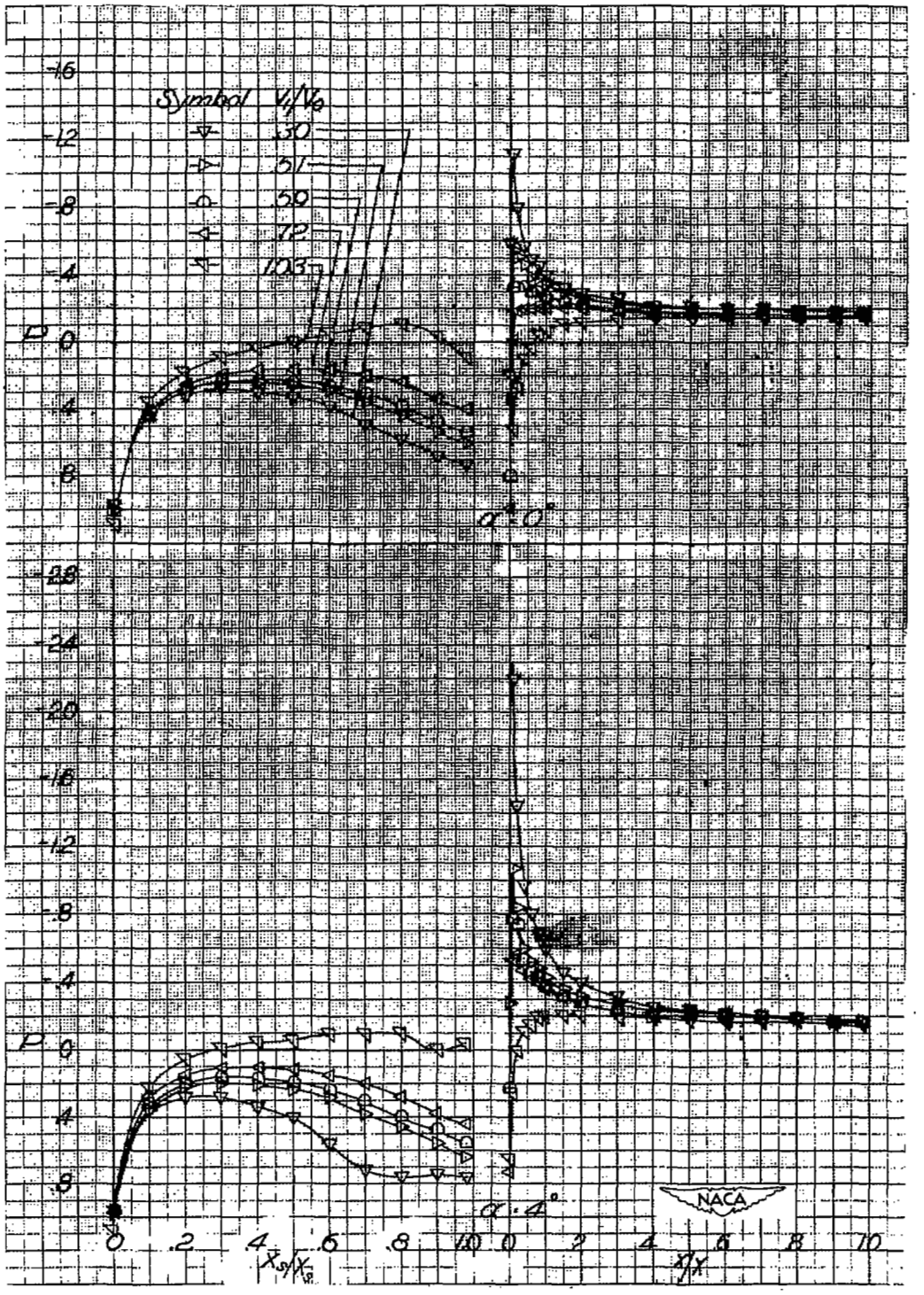


Figure 71.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-30-040 spinner.

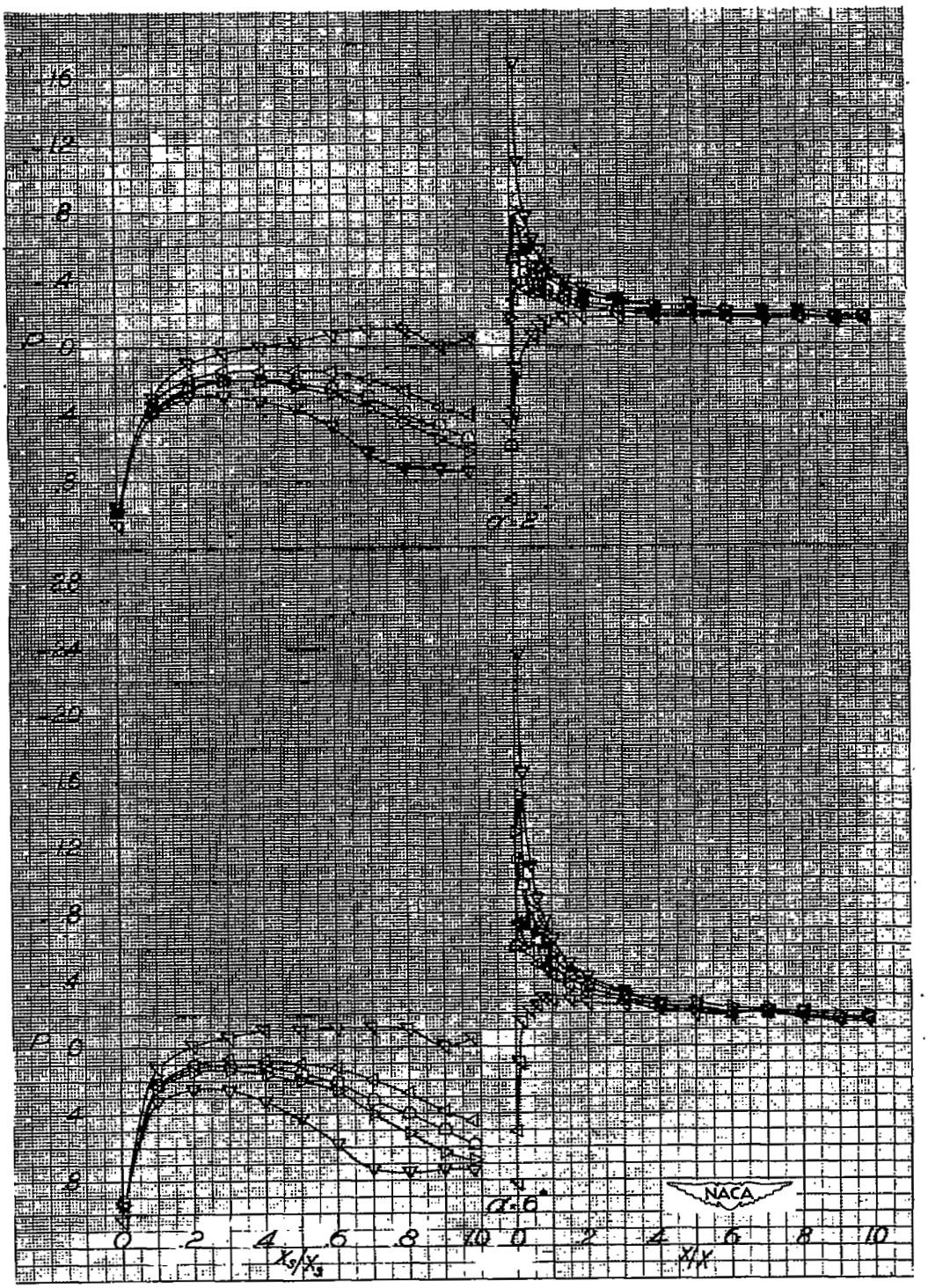


Figure 71.- Concluded.

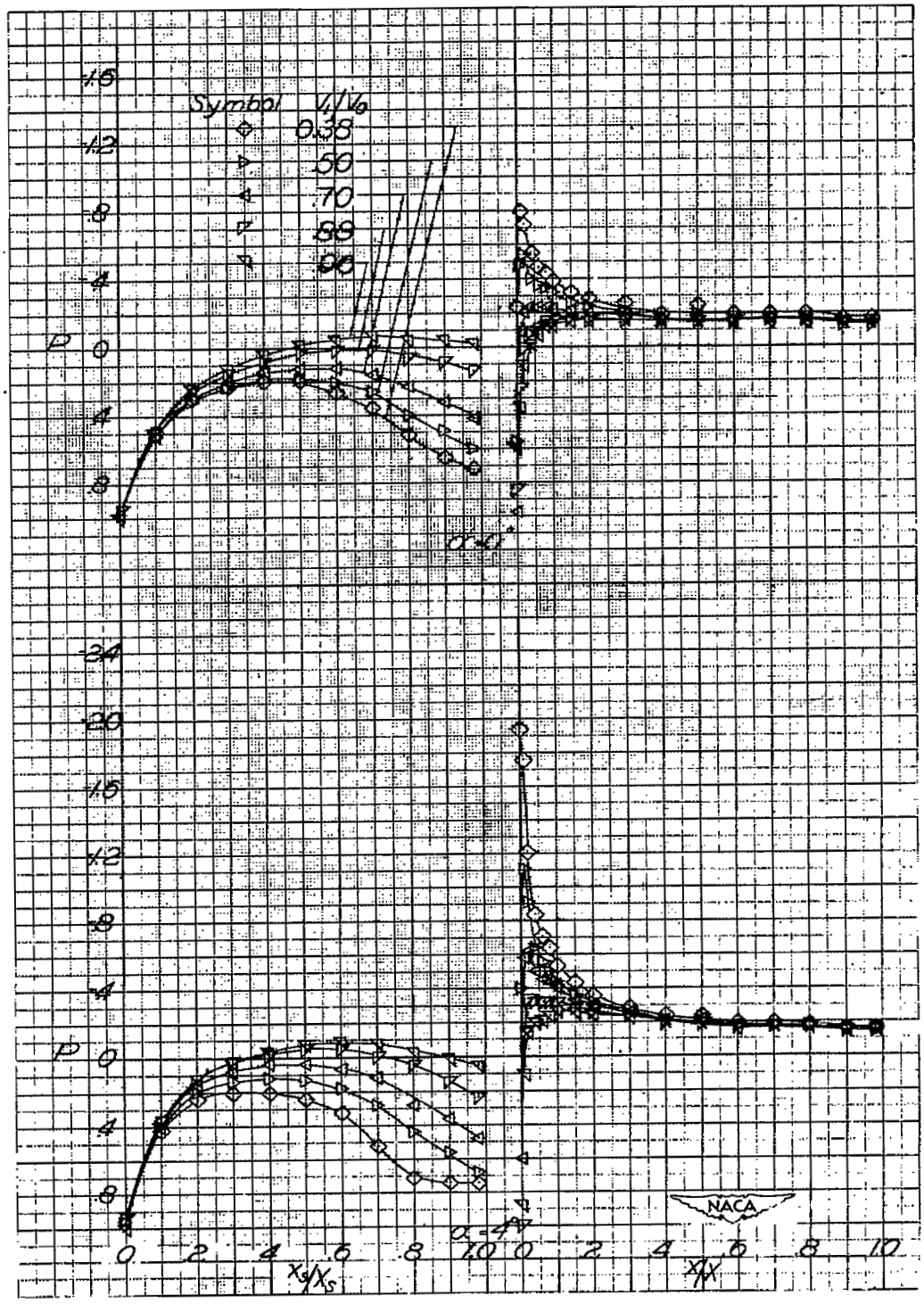


Figure 72.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-40-040 spinner

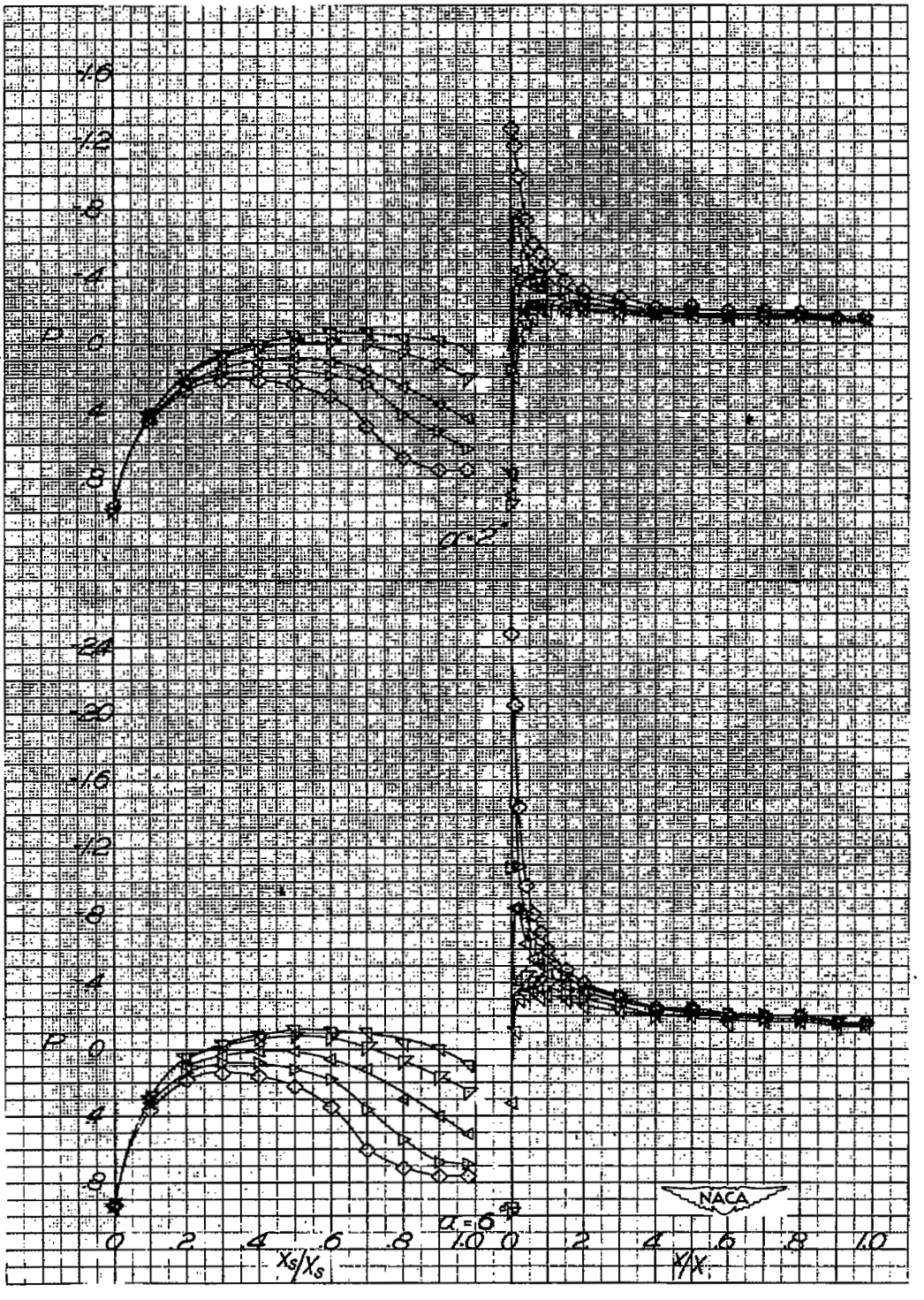


Figure 72.- Concluded.

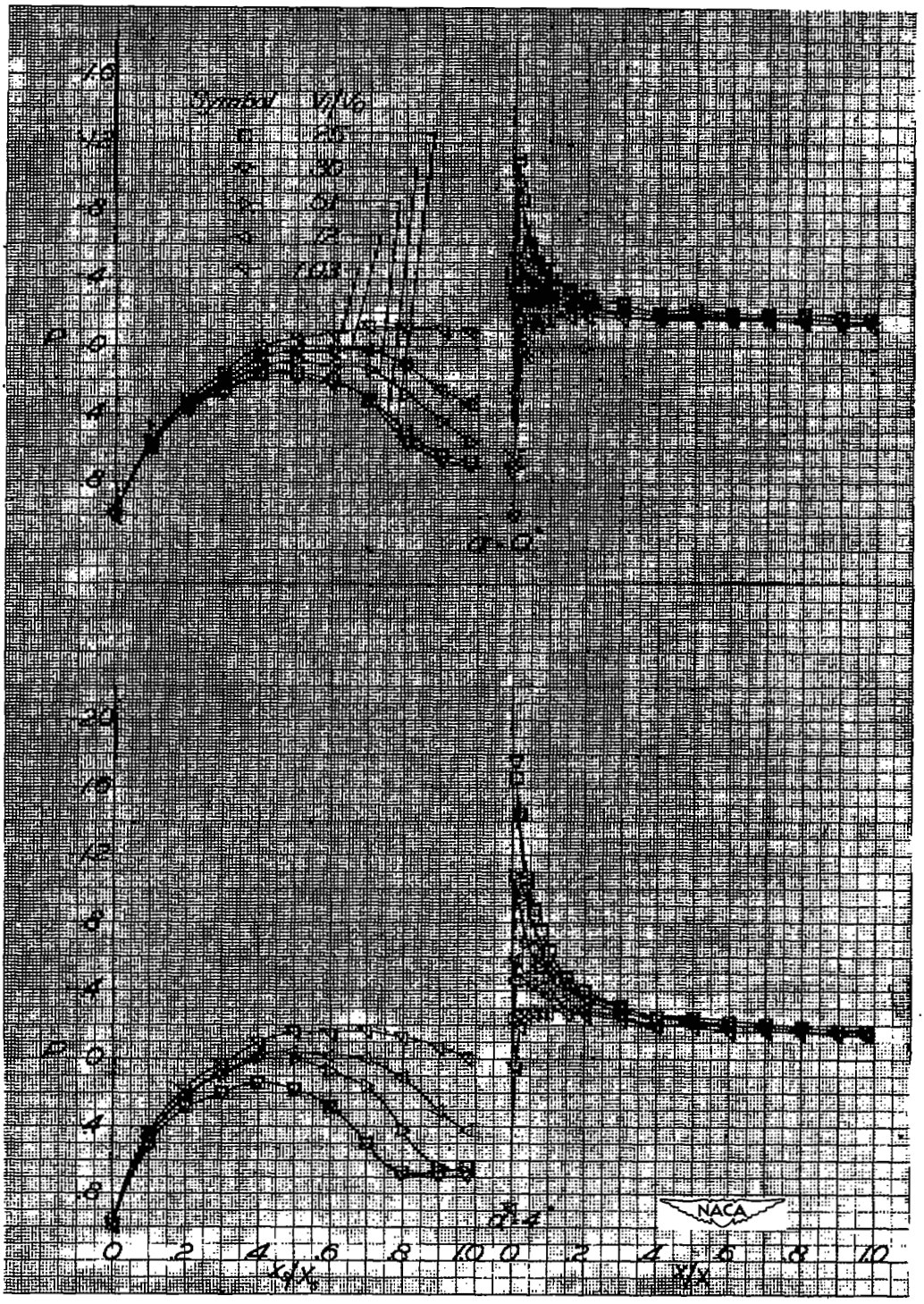


Figure 73.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-50-040 spinner.

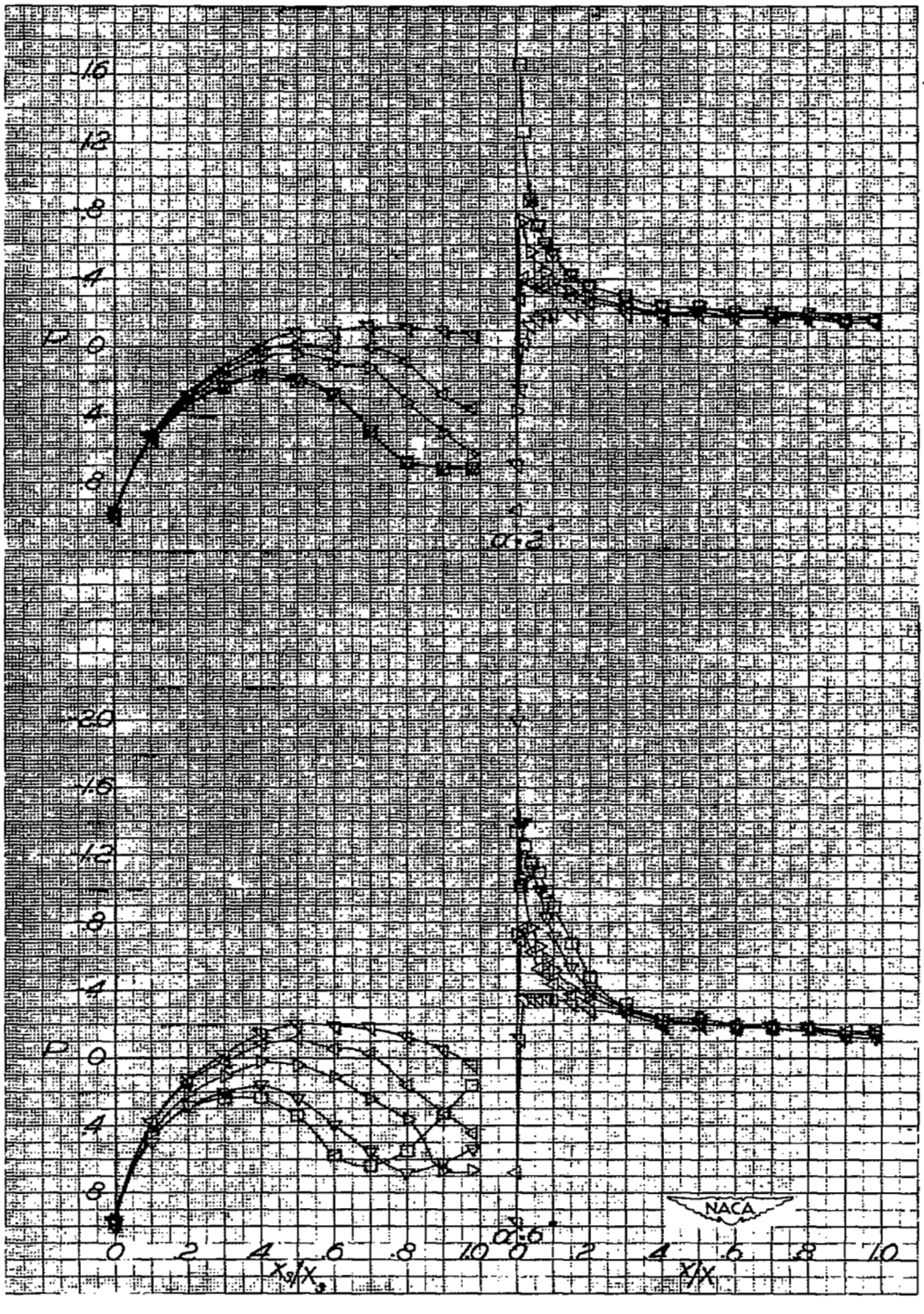


Figure 73.- Concluded.

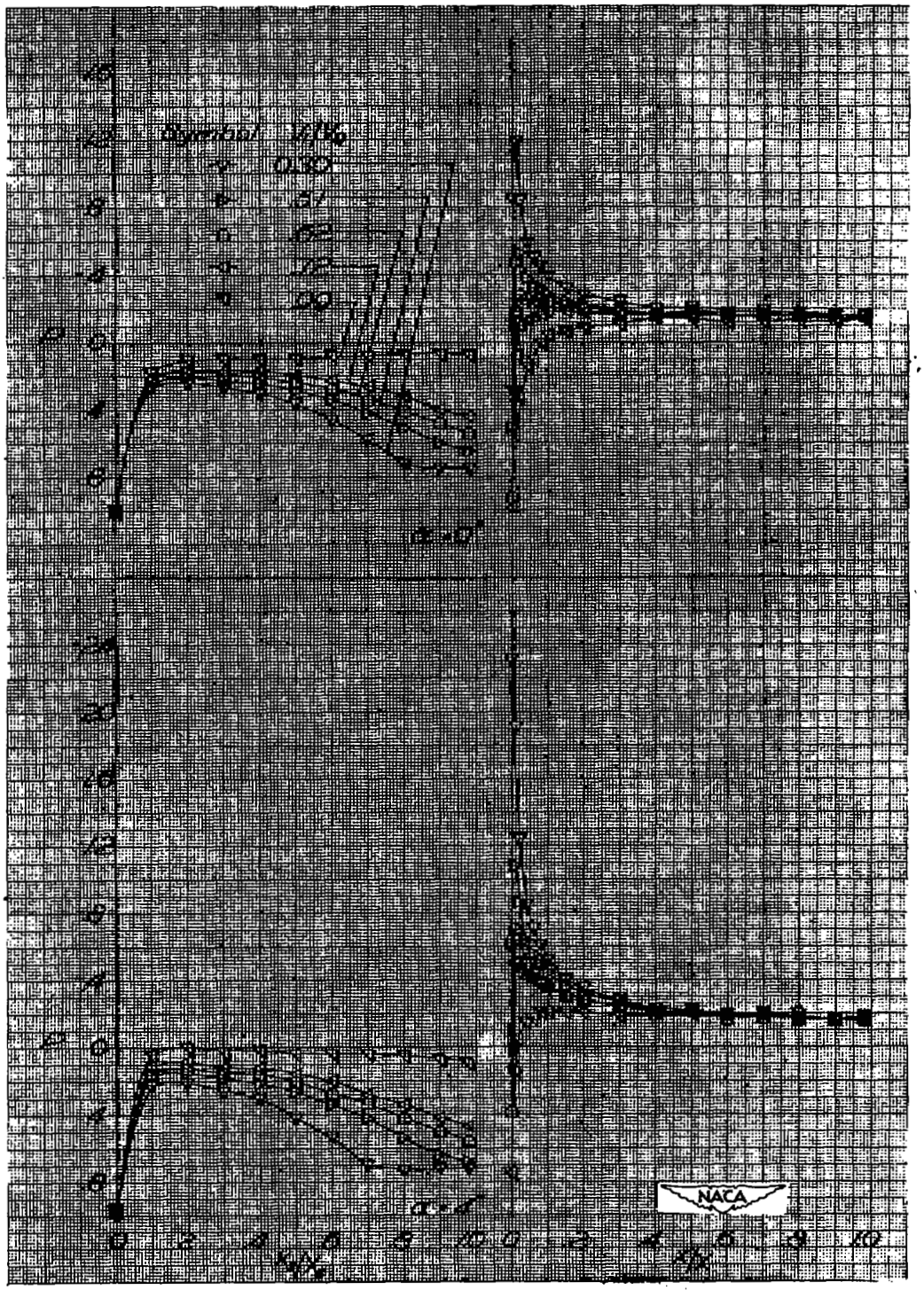


Figure 74.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-20-060 spinner.

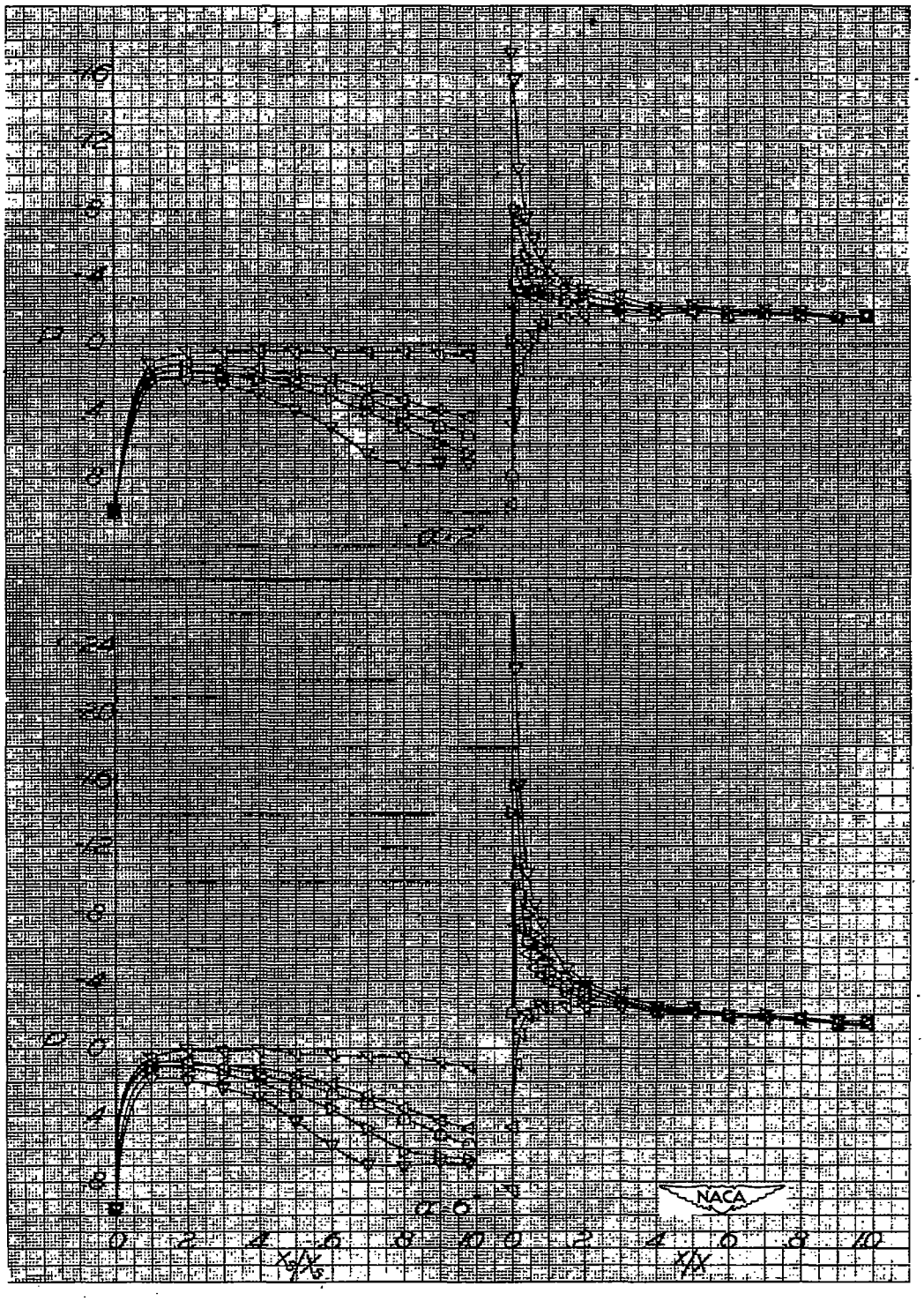


Figure 74.- Concluded.

Figure 75.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-30-060 spinner.

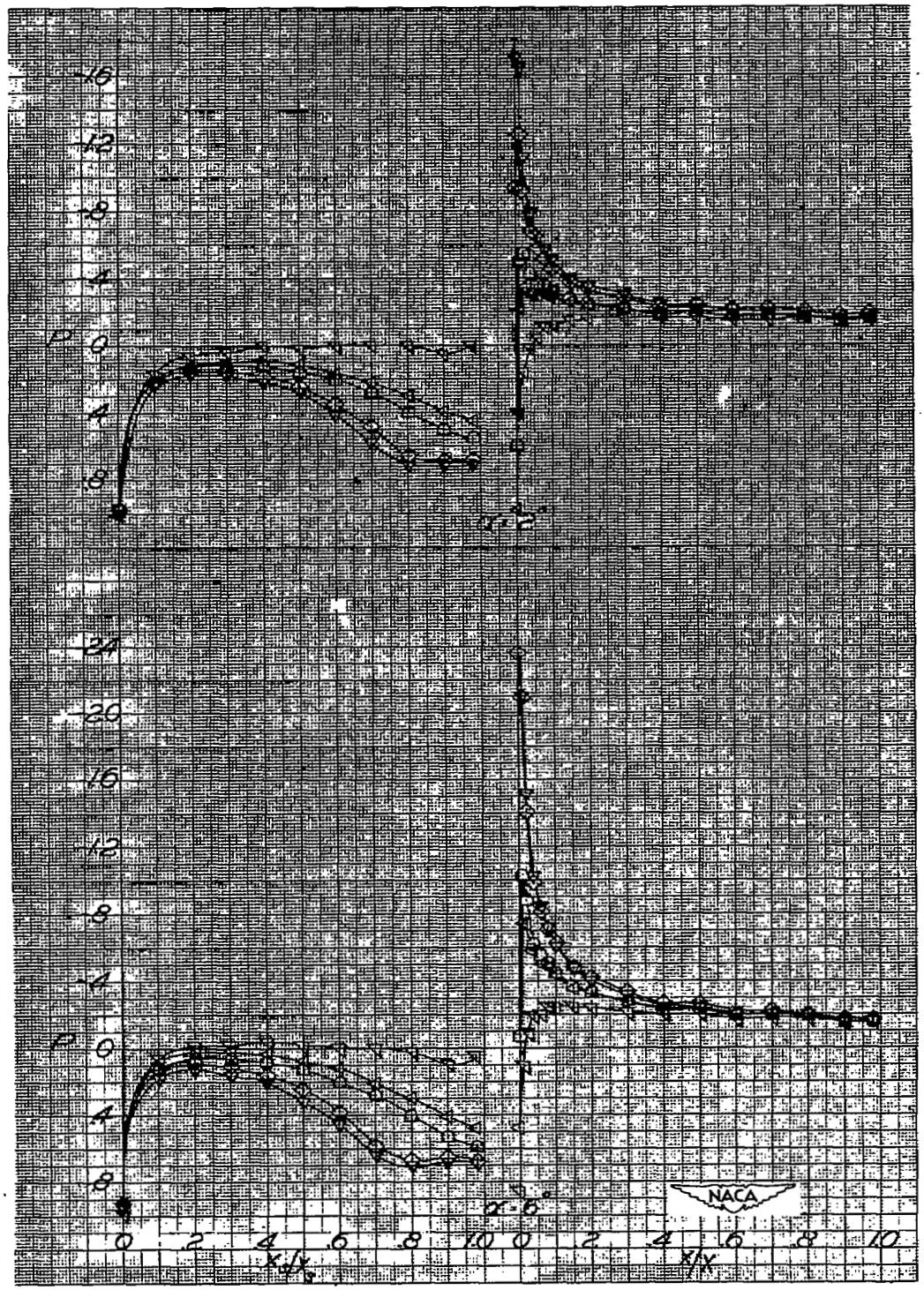


Figure 75.- Concluded.

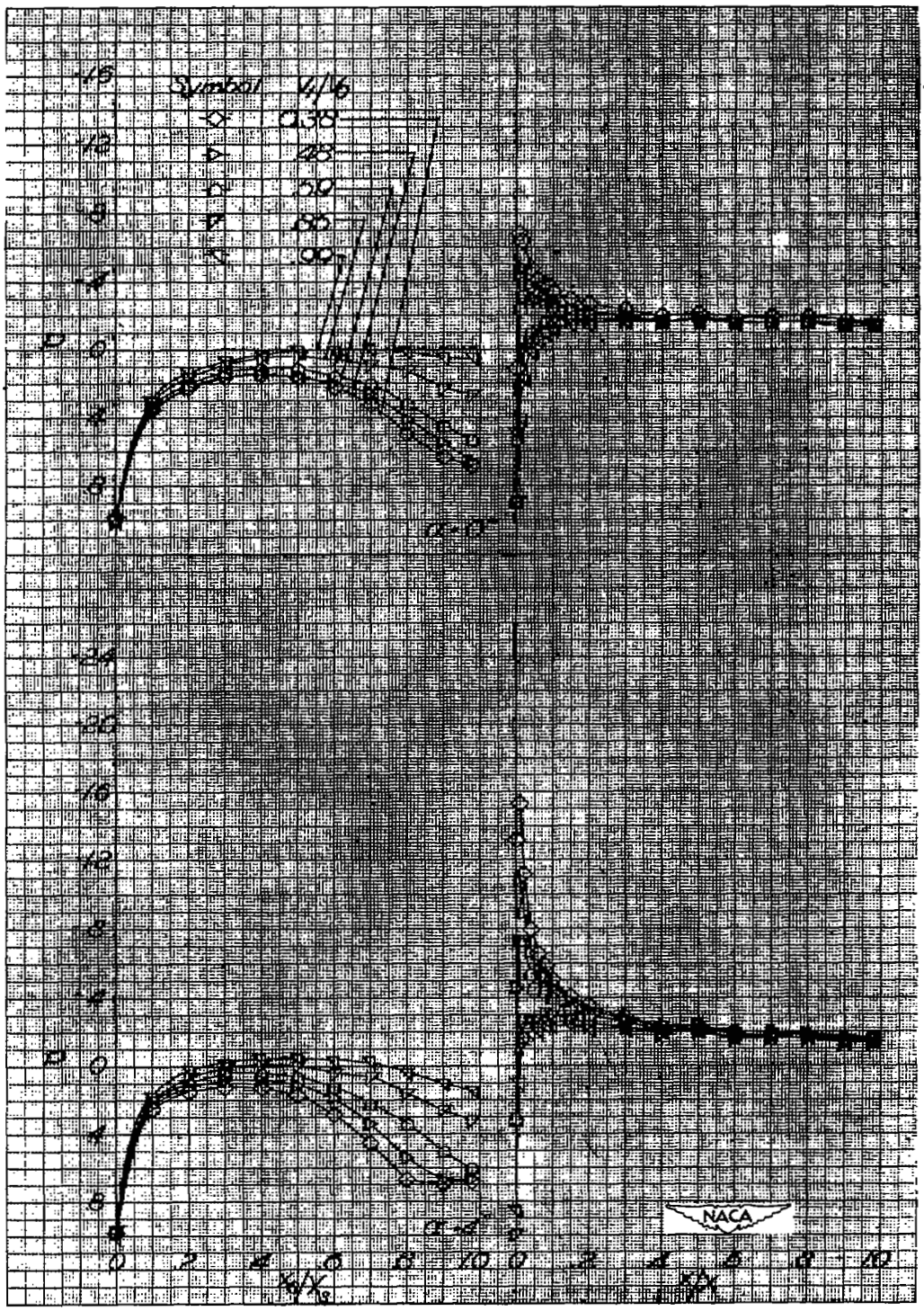


Figure 76.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-40-060 spinner.

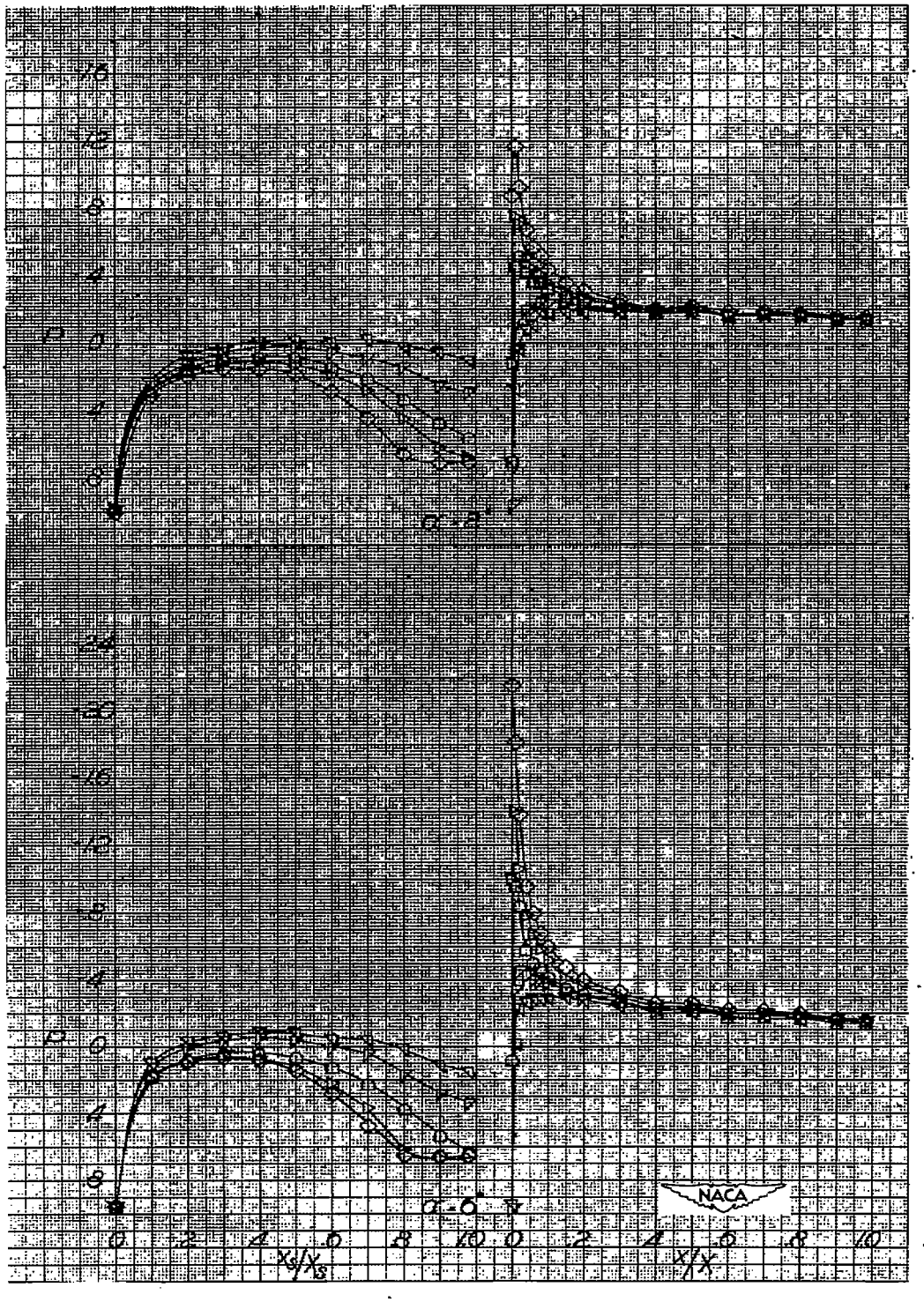


Figure 76.- Concluded.

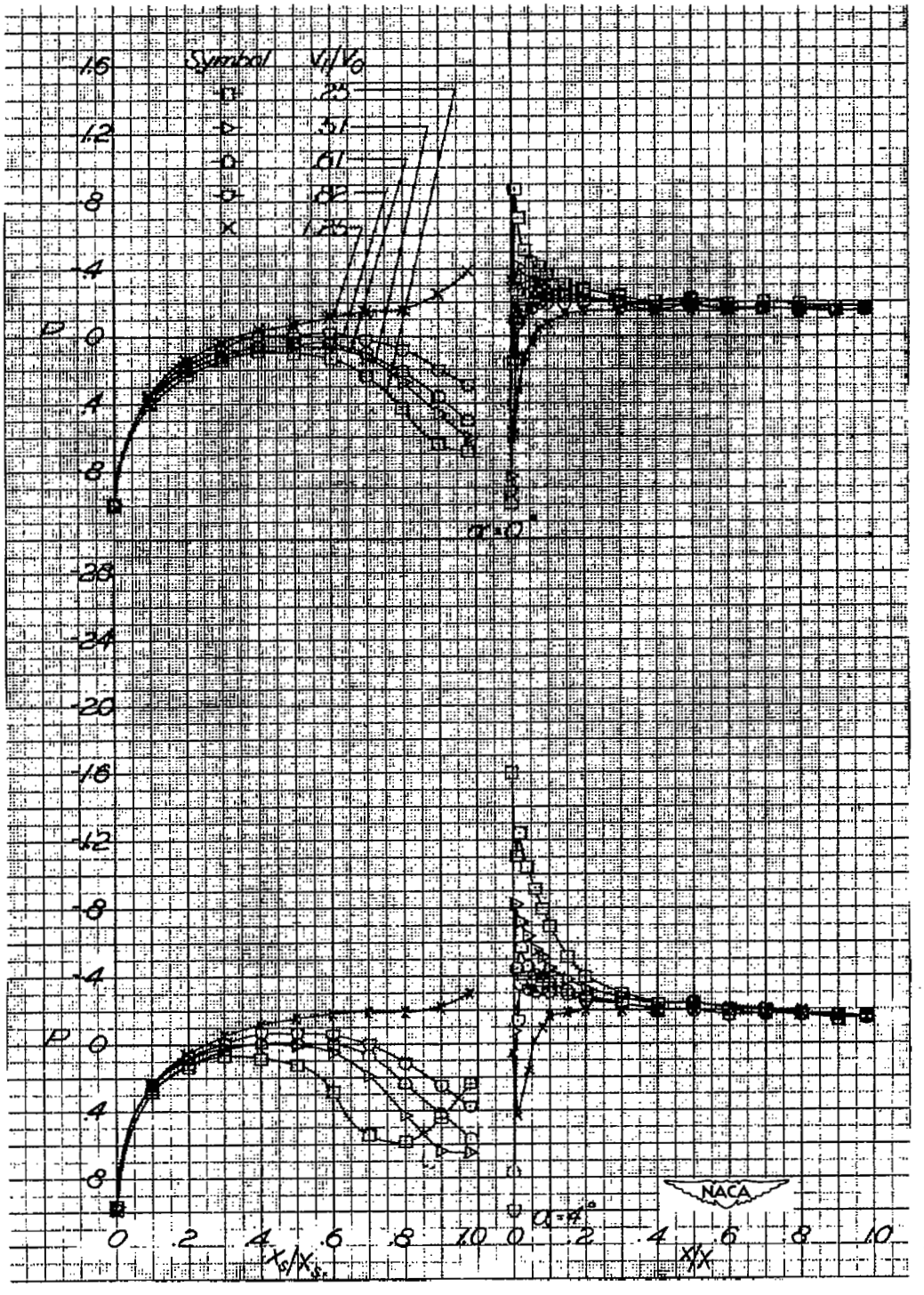


Figure 77.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-50-060 spinner.

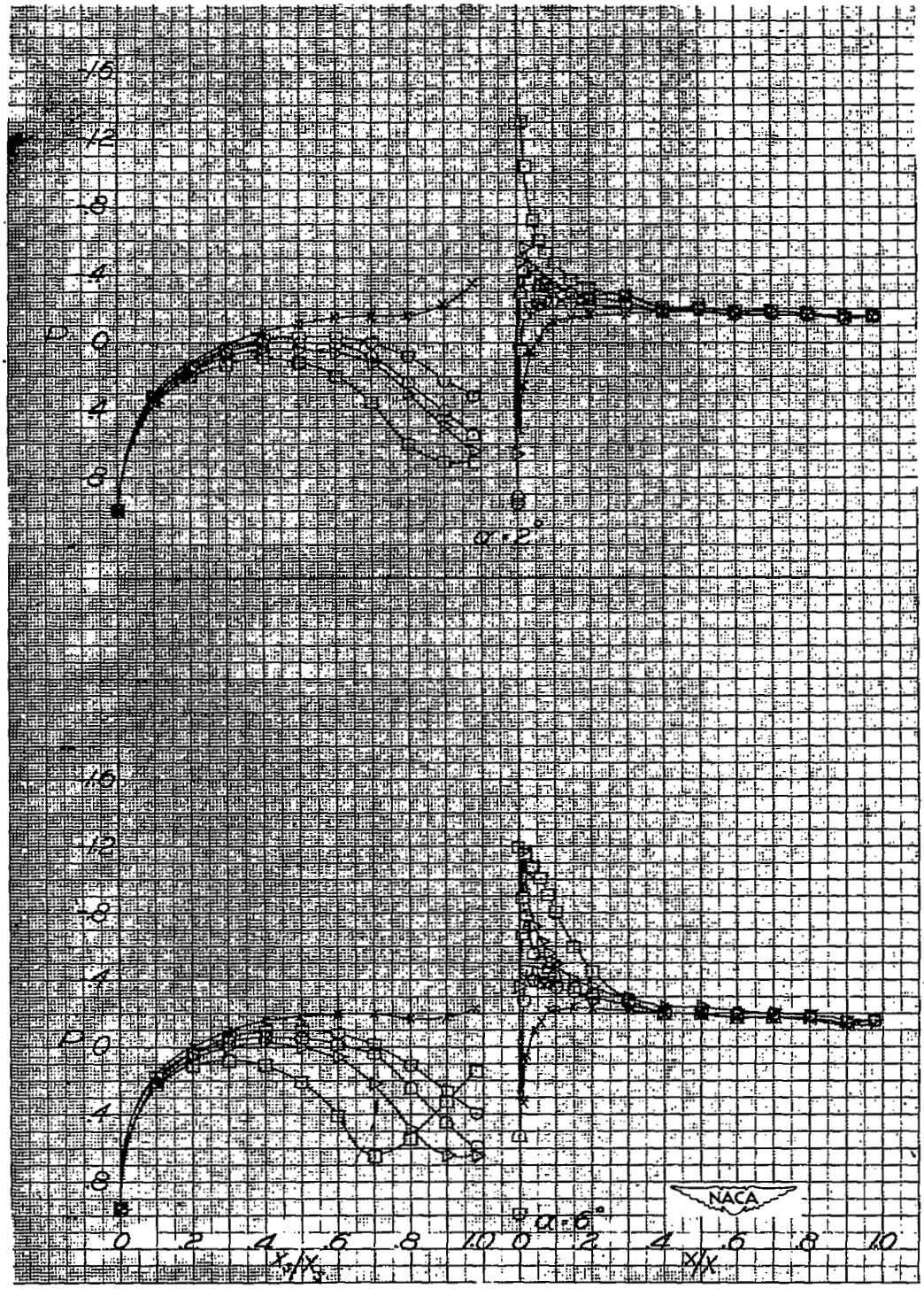


Figure 77.- Concluded.

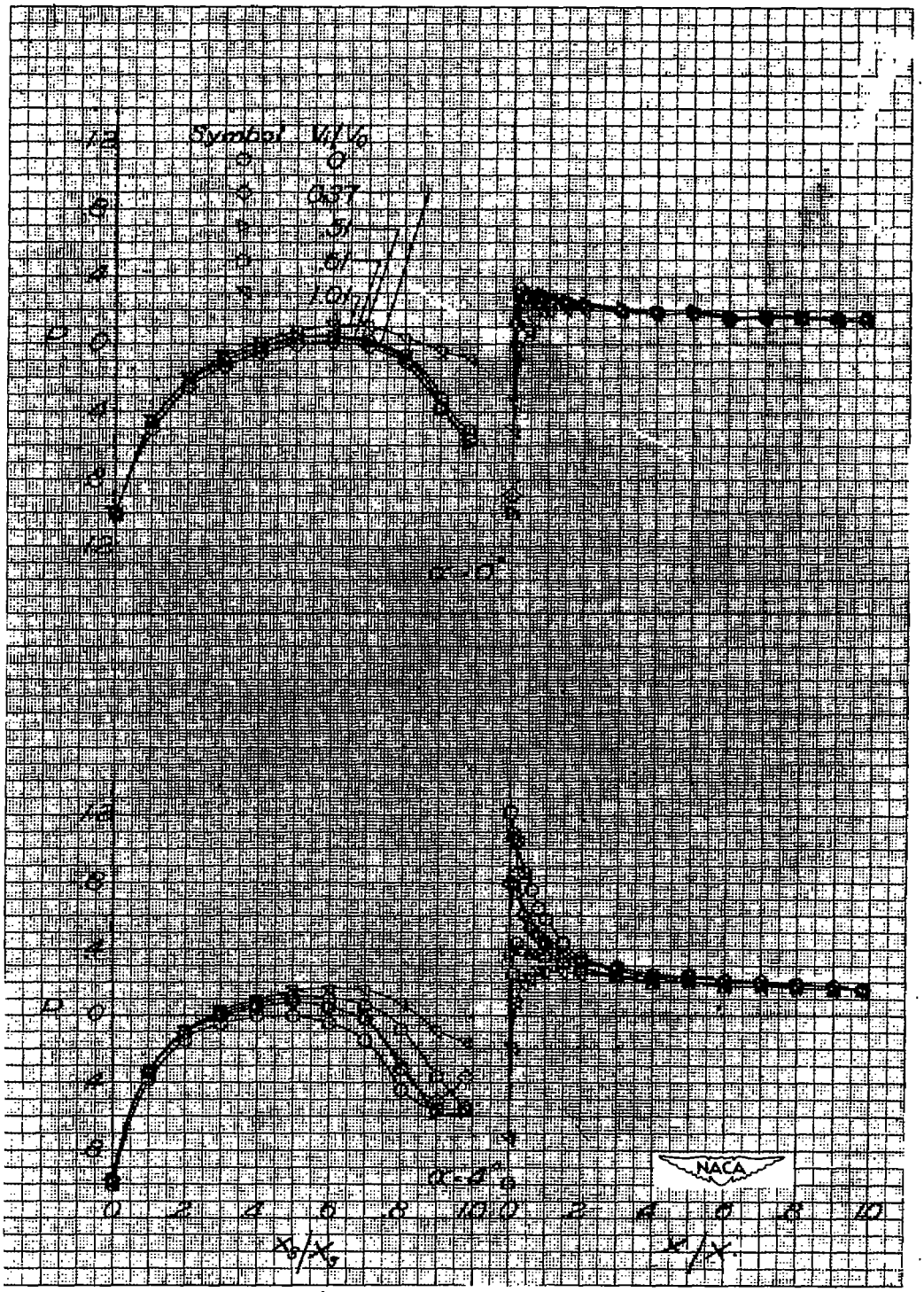


Figure 78.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-60-060 spinner.

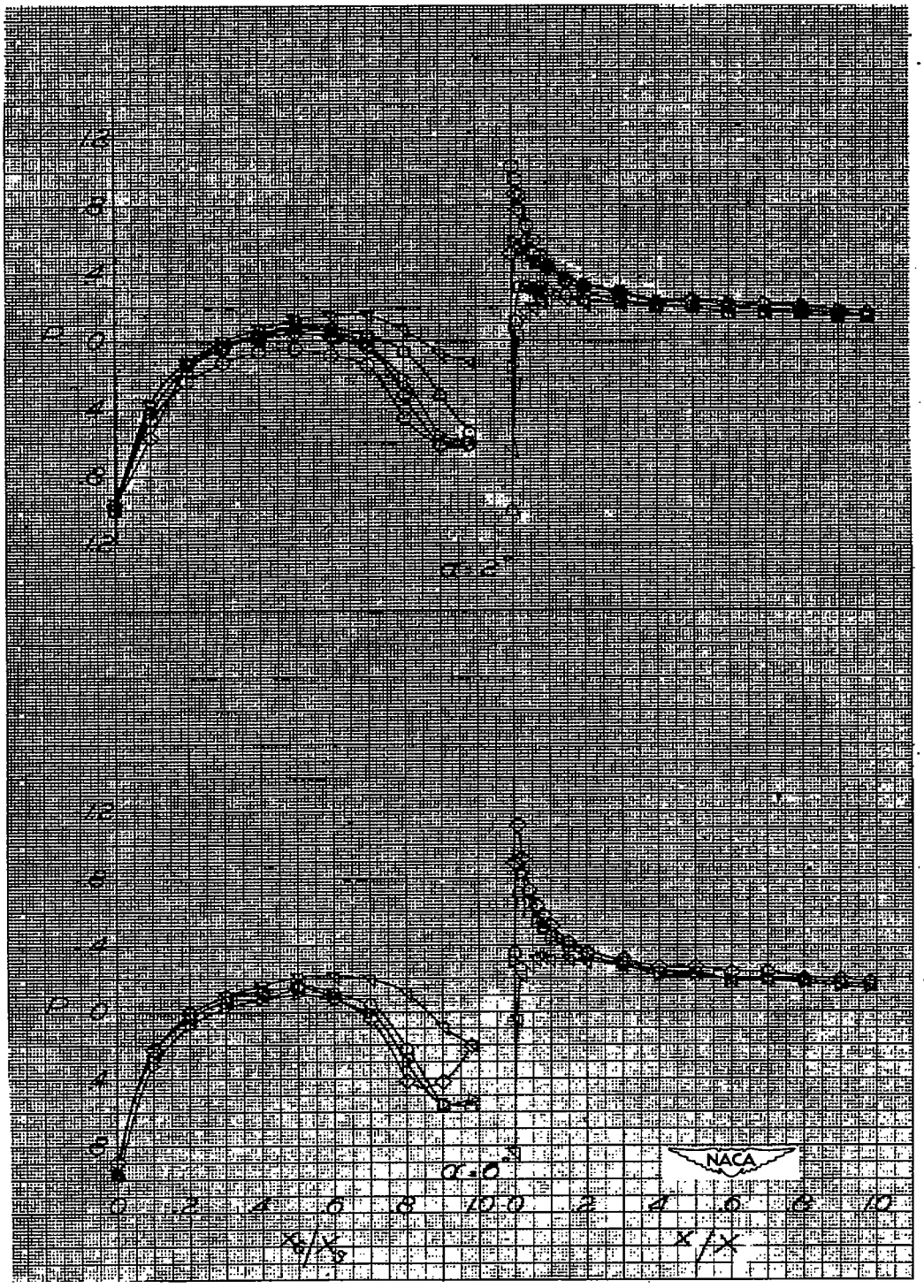


Figure 78.- Concluded.

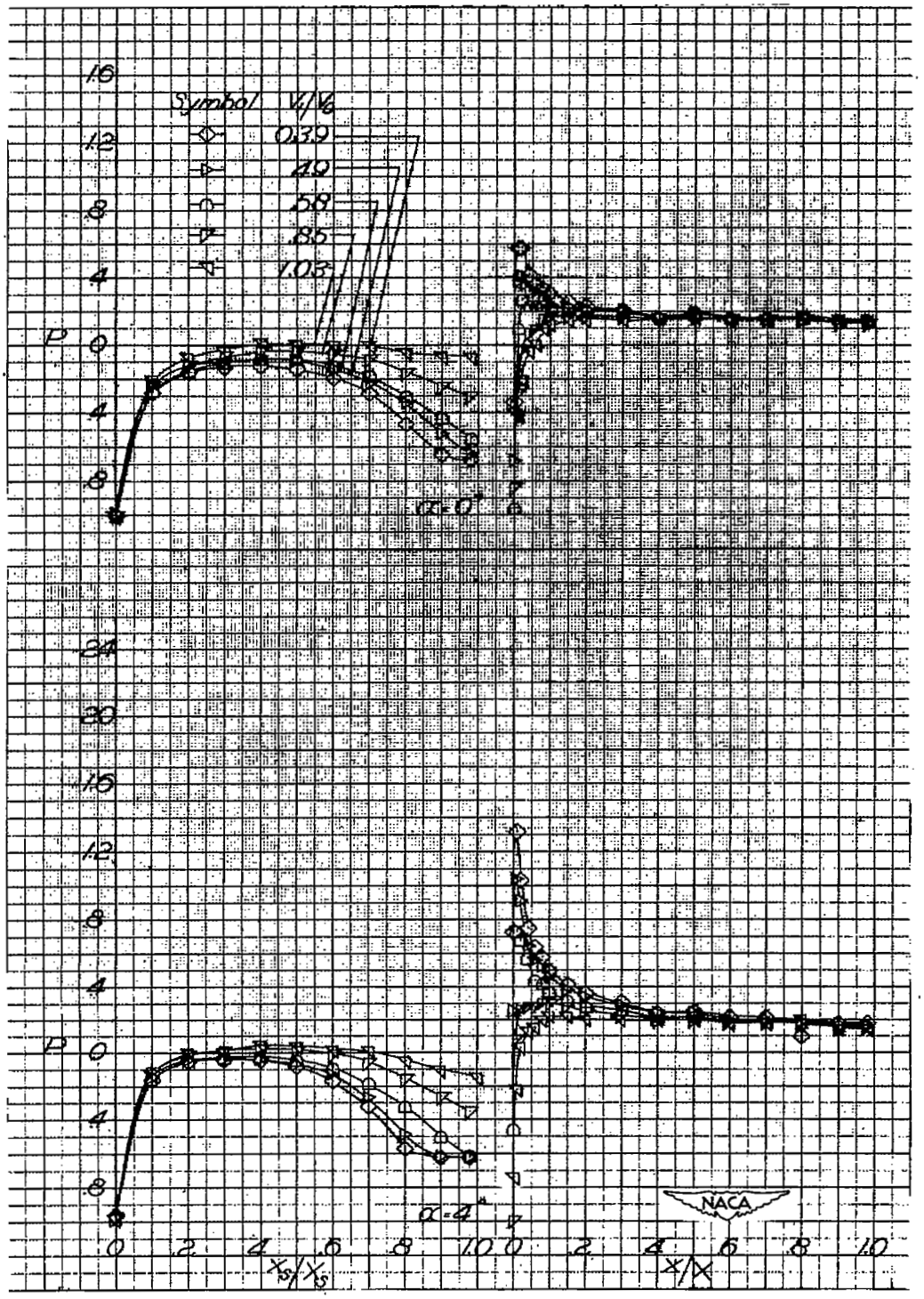


Figure 79.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-40-080 spinner.

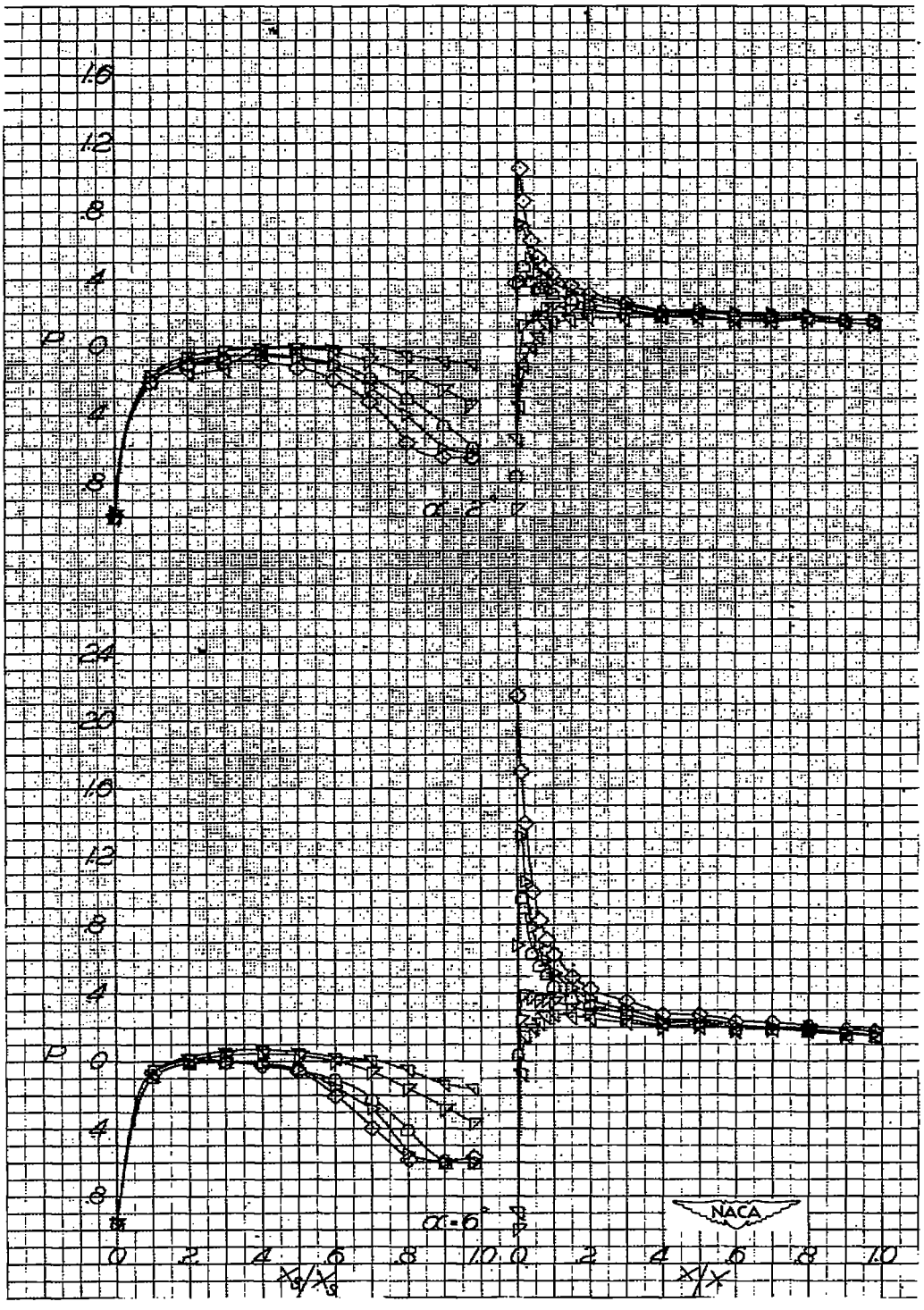


Figure 79.- Concluded.

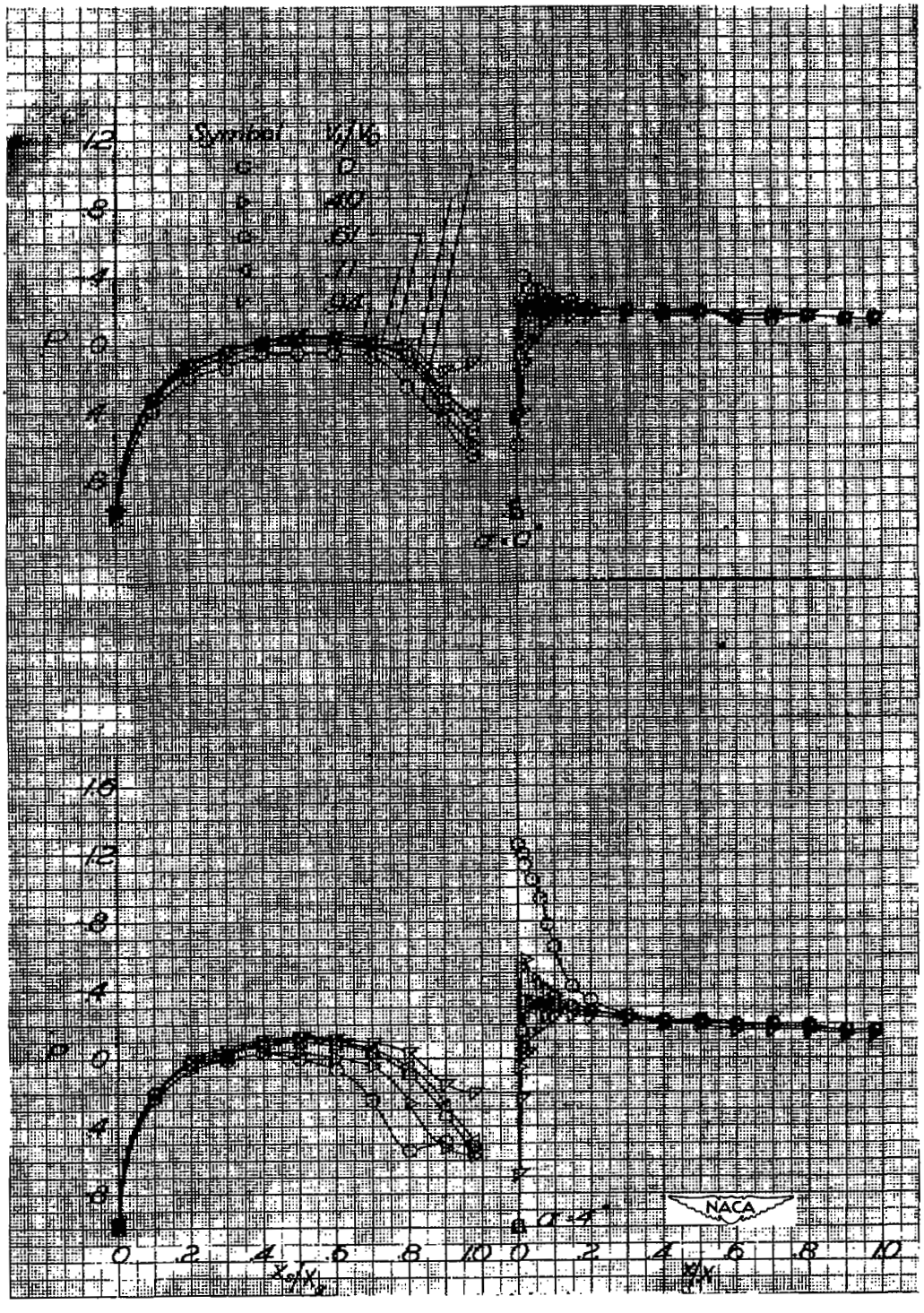


Figure 80.- Static-pressure distributions on top of NACA 1-70-100 cowling with NACA 1-60-080 spinner.

Figure 80.- Concluded.

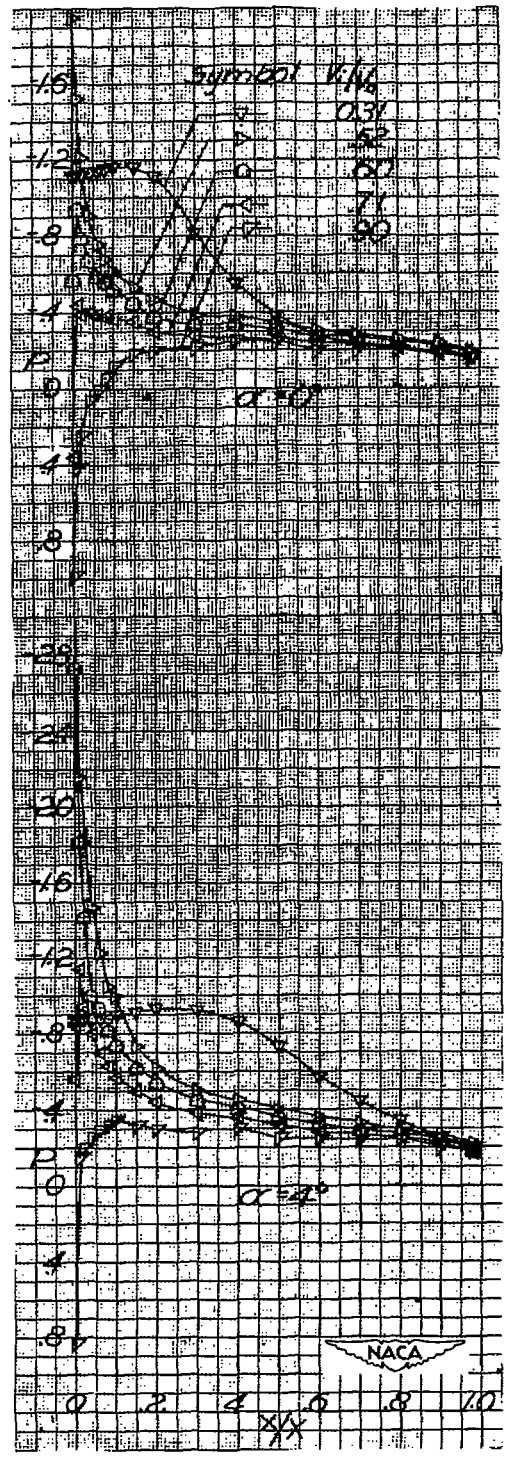


Figure 81.- Static-pressure distributions on top of NACA 1-85-050 open-nose cowling.

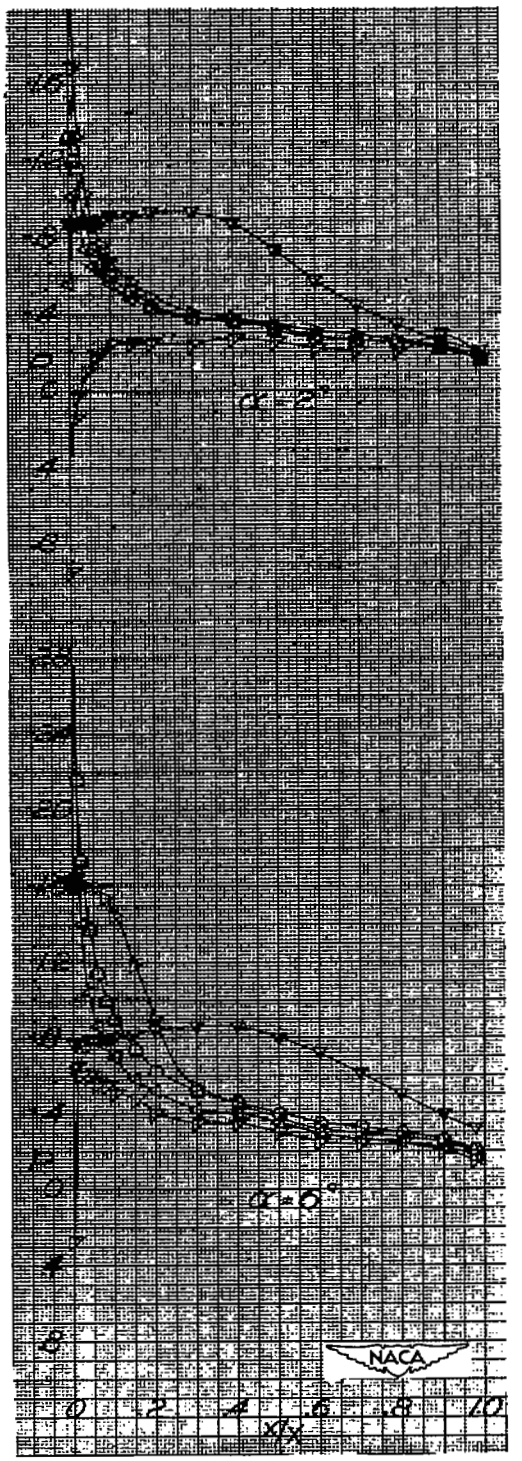


Figure 81.- Concluded.

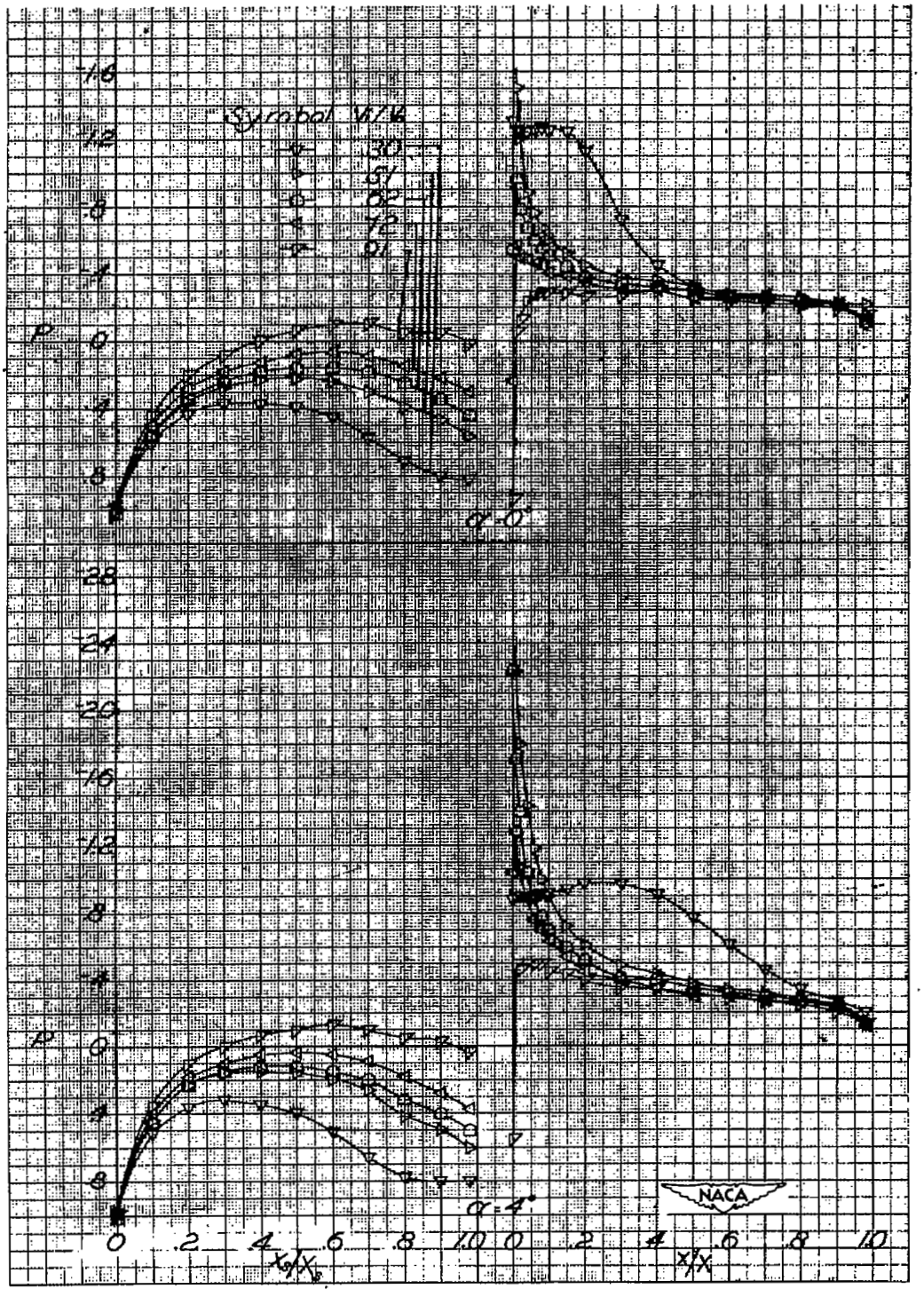


Figure 82.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-40-040 spinner.

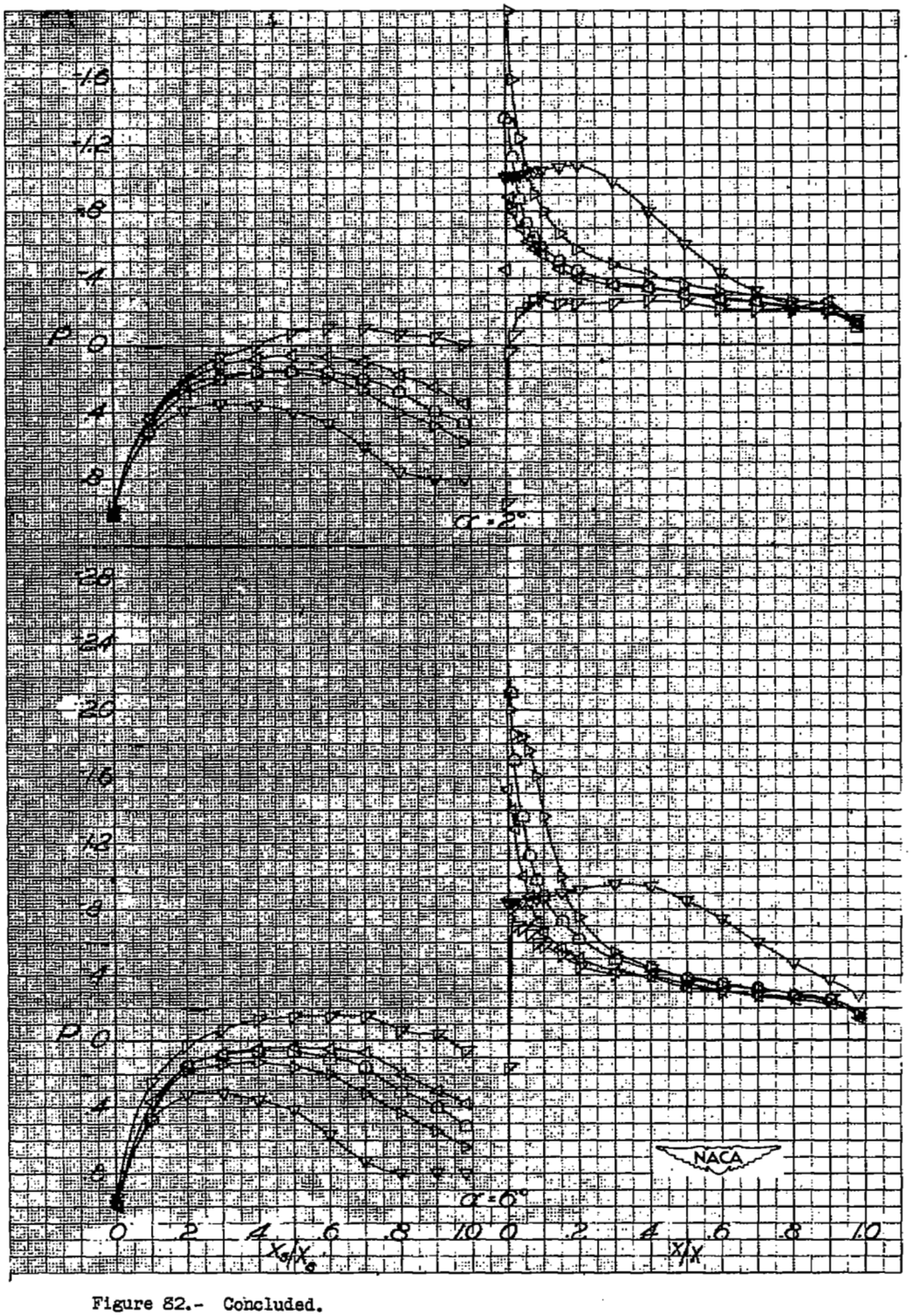


Figure 82.- Concluded.

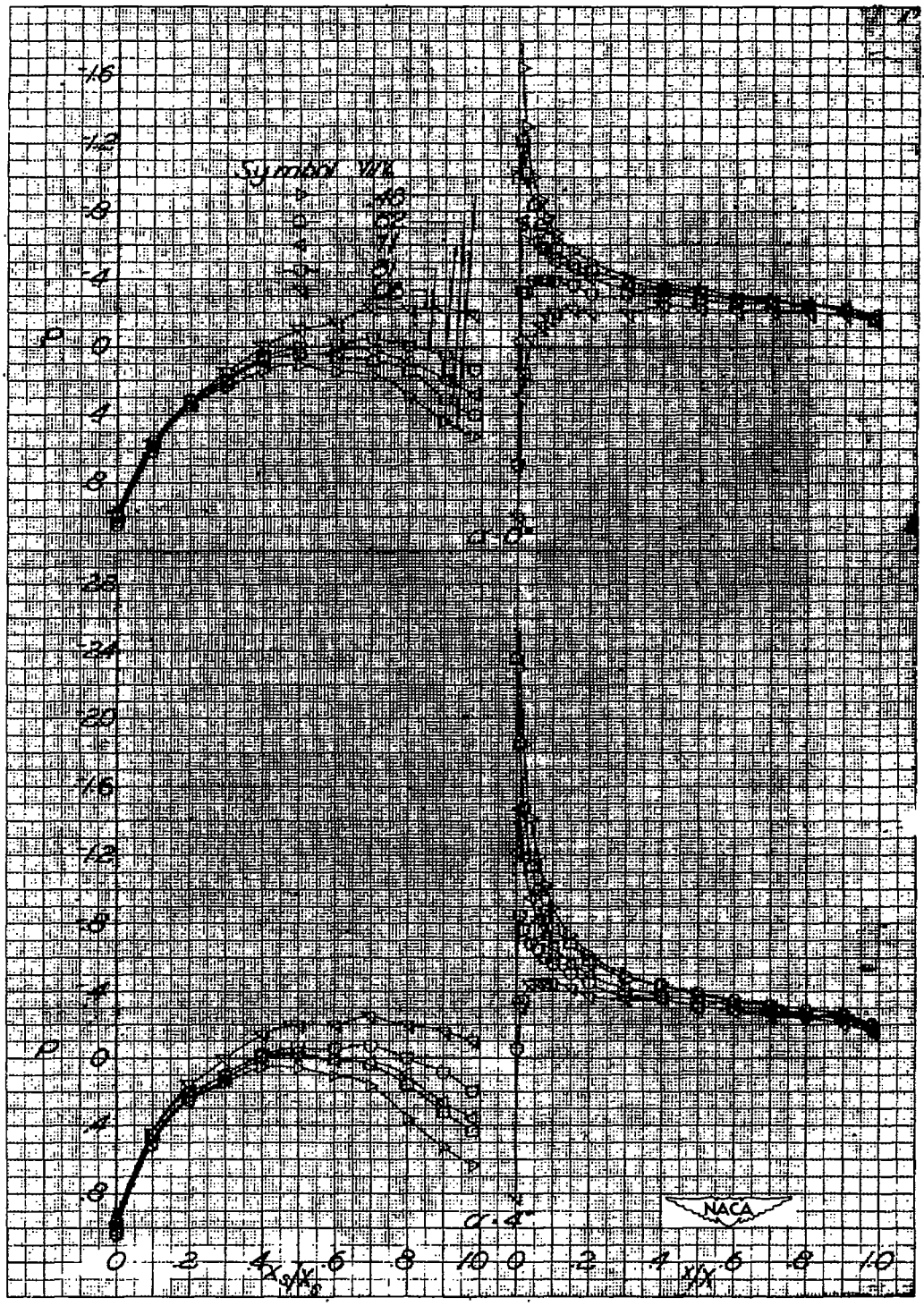


Figure 83.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-50-040 spinner.

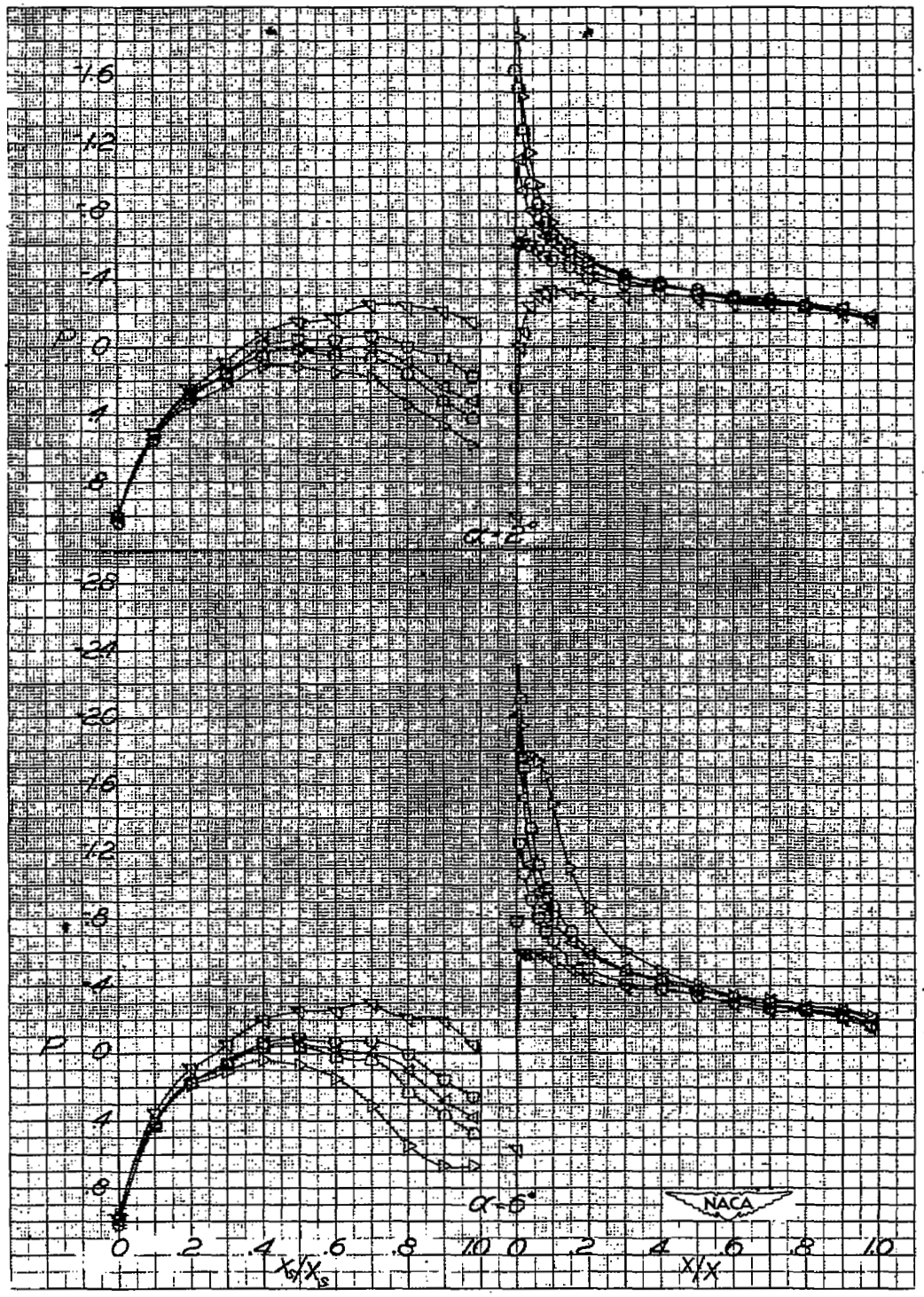


Figure 83.- Concluded.

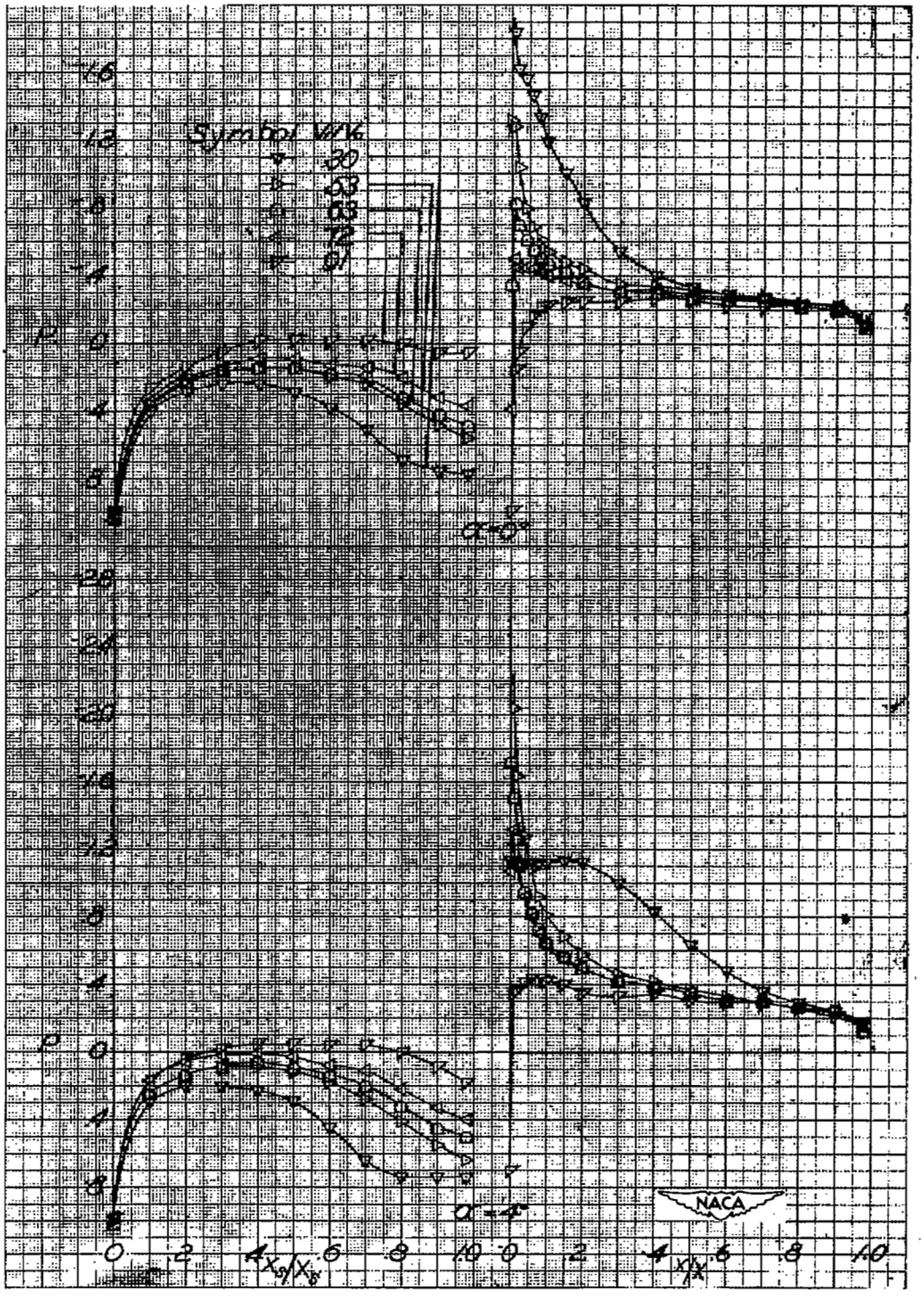


Figure 84.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-40-060 spinner.

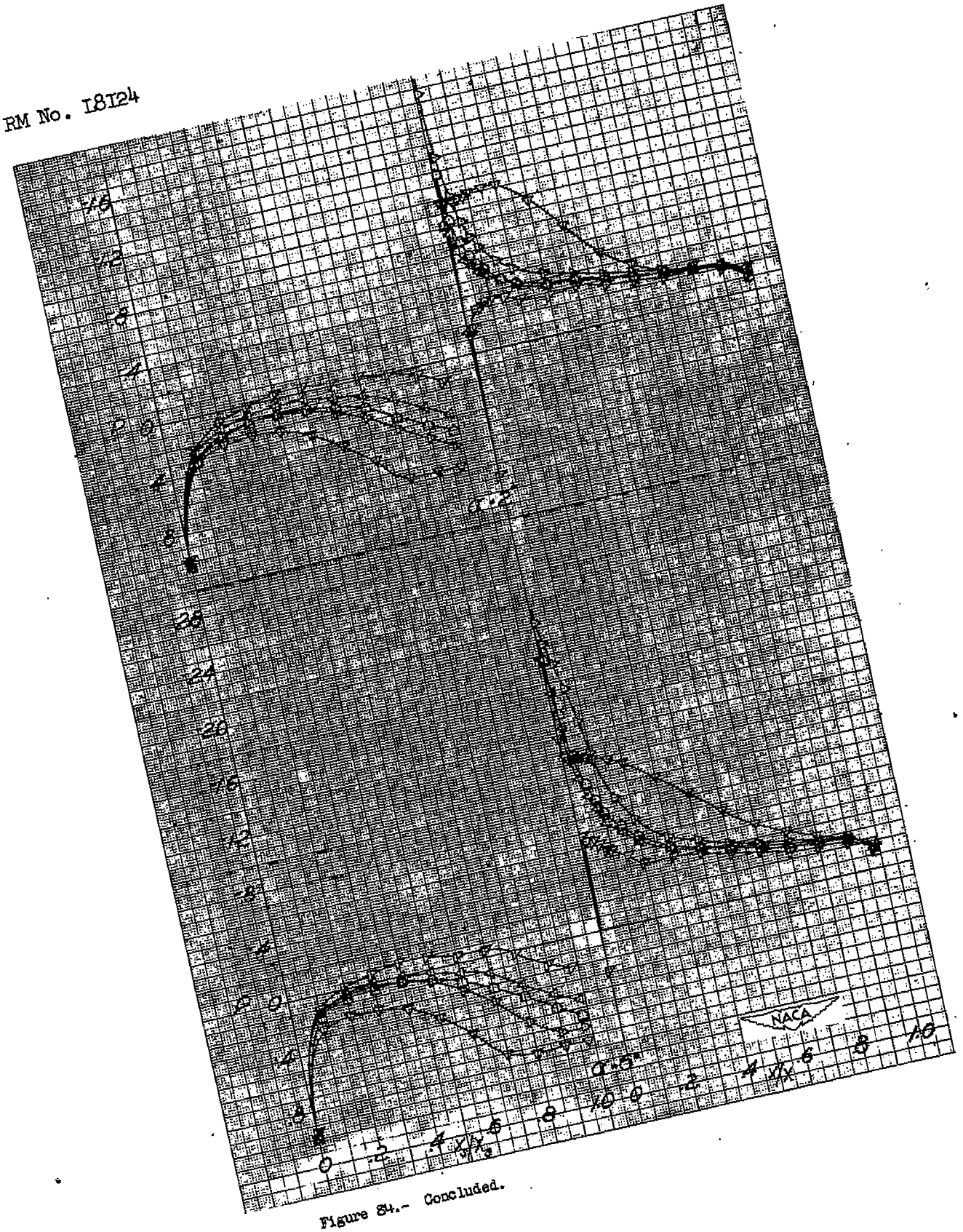


Figure 84.- Concluded.

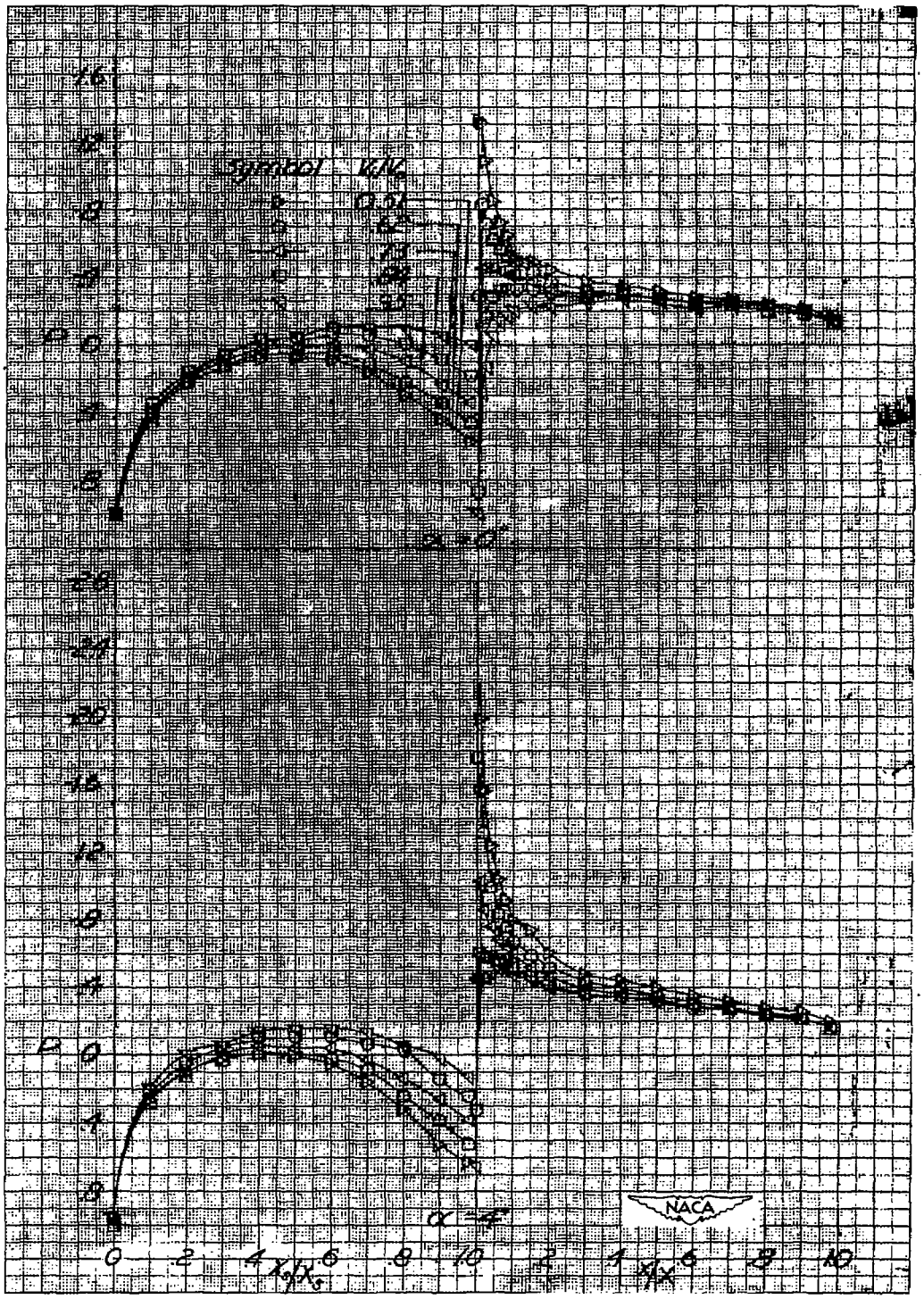


Figure 85.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-50-060 spinner.

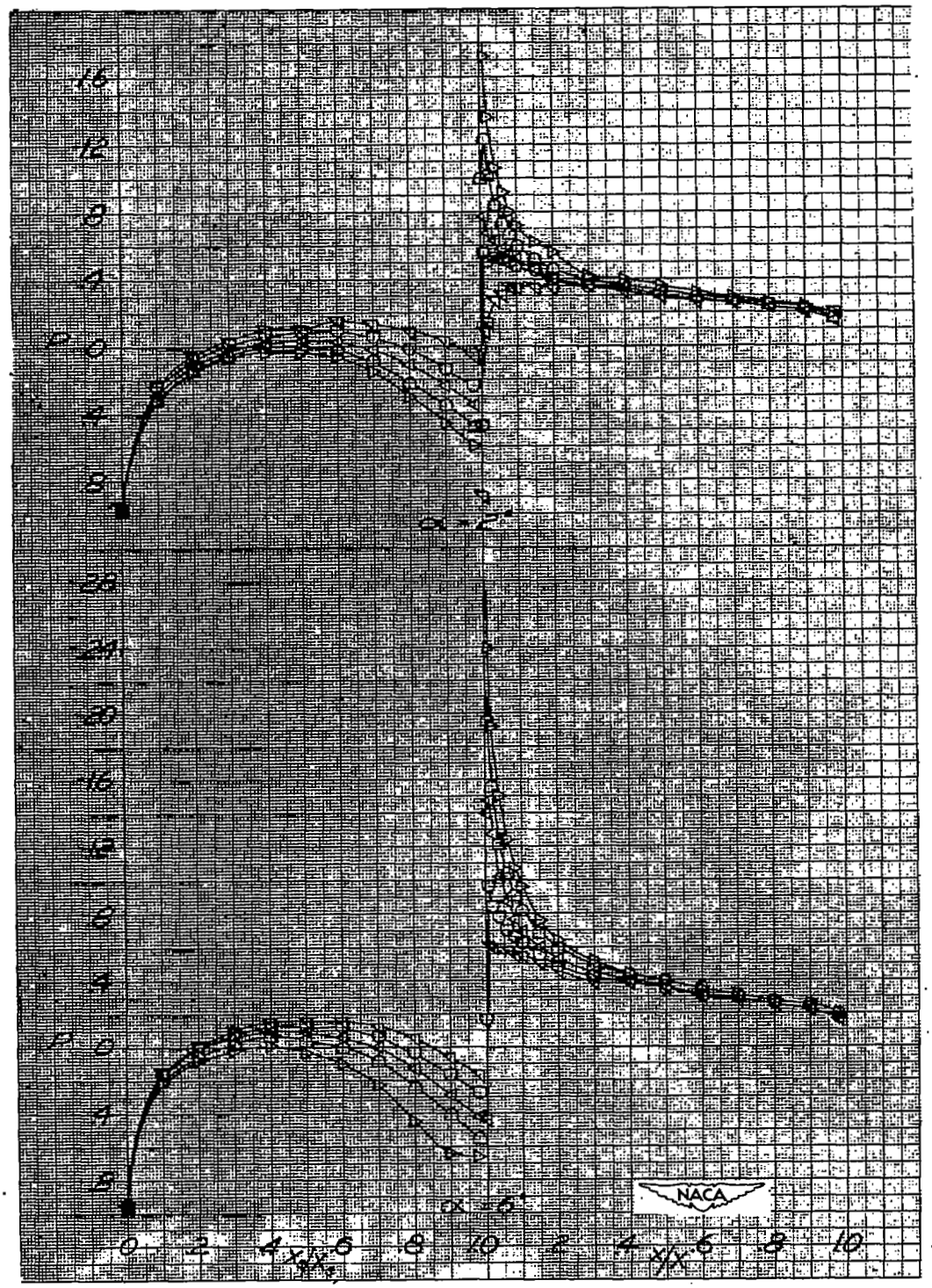


Figure 85.- Concluded.

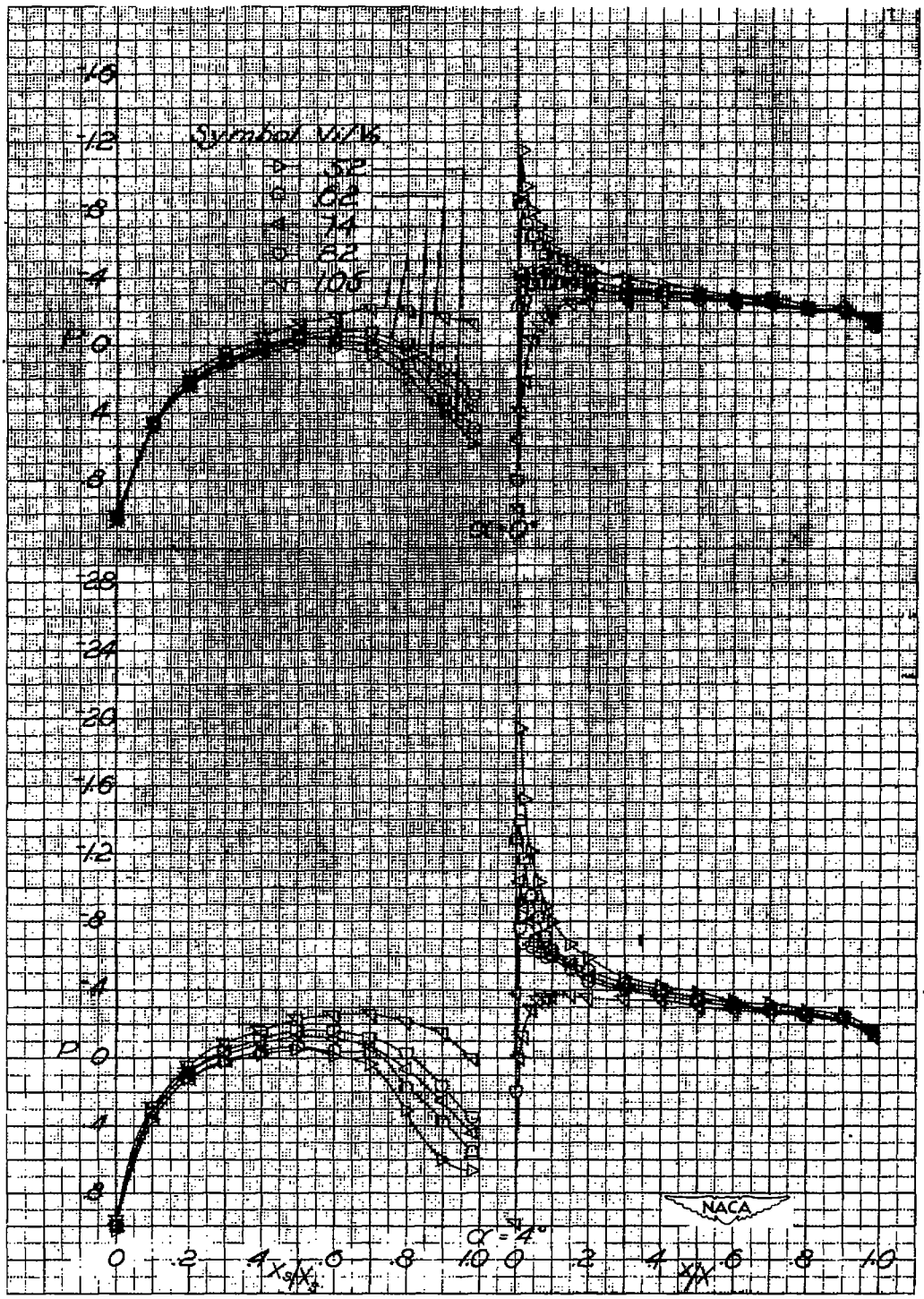


Figure 86.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-60-060 spinner.

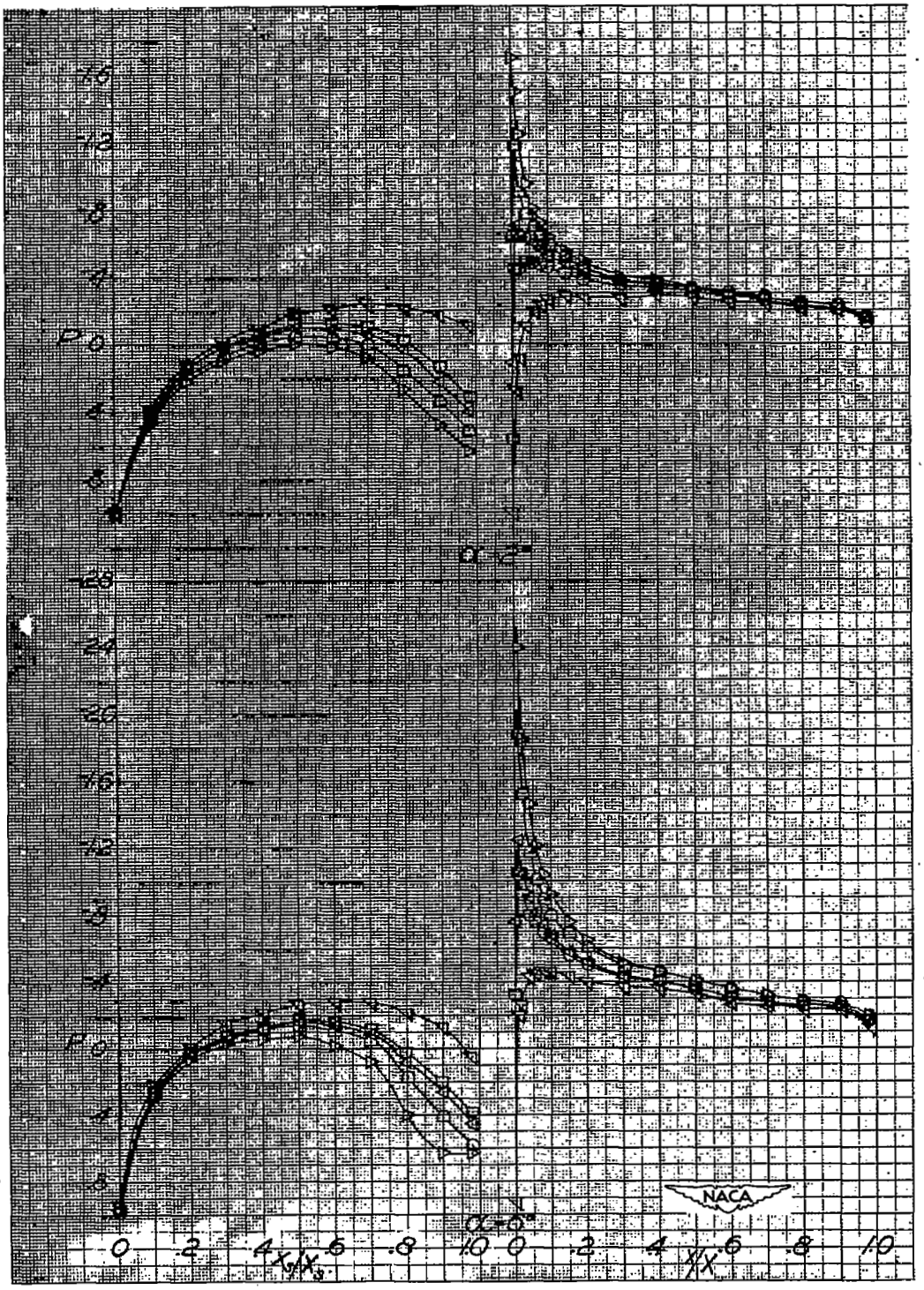


Figure 86.- Concluded.

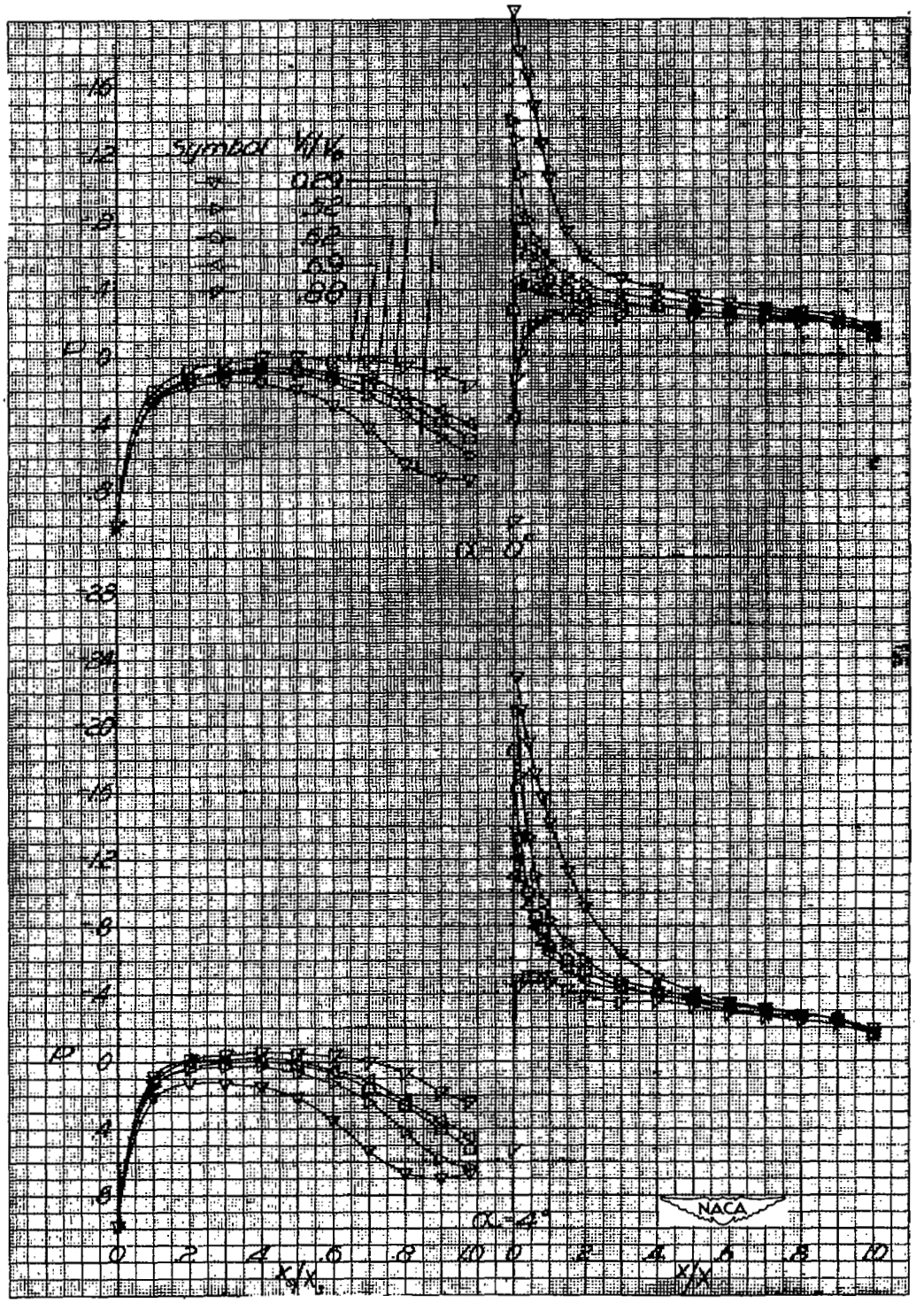


Figure 87.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-40-080 spinner.

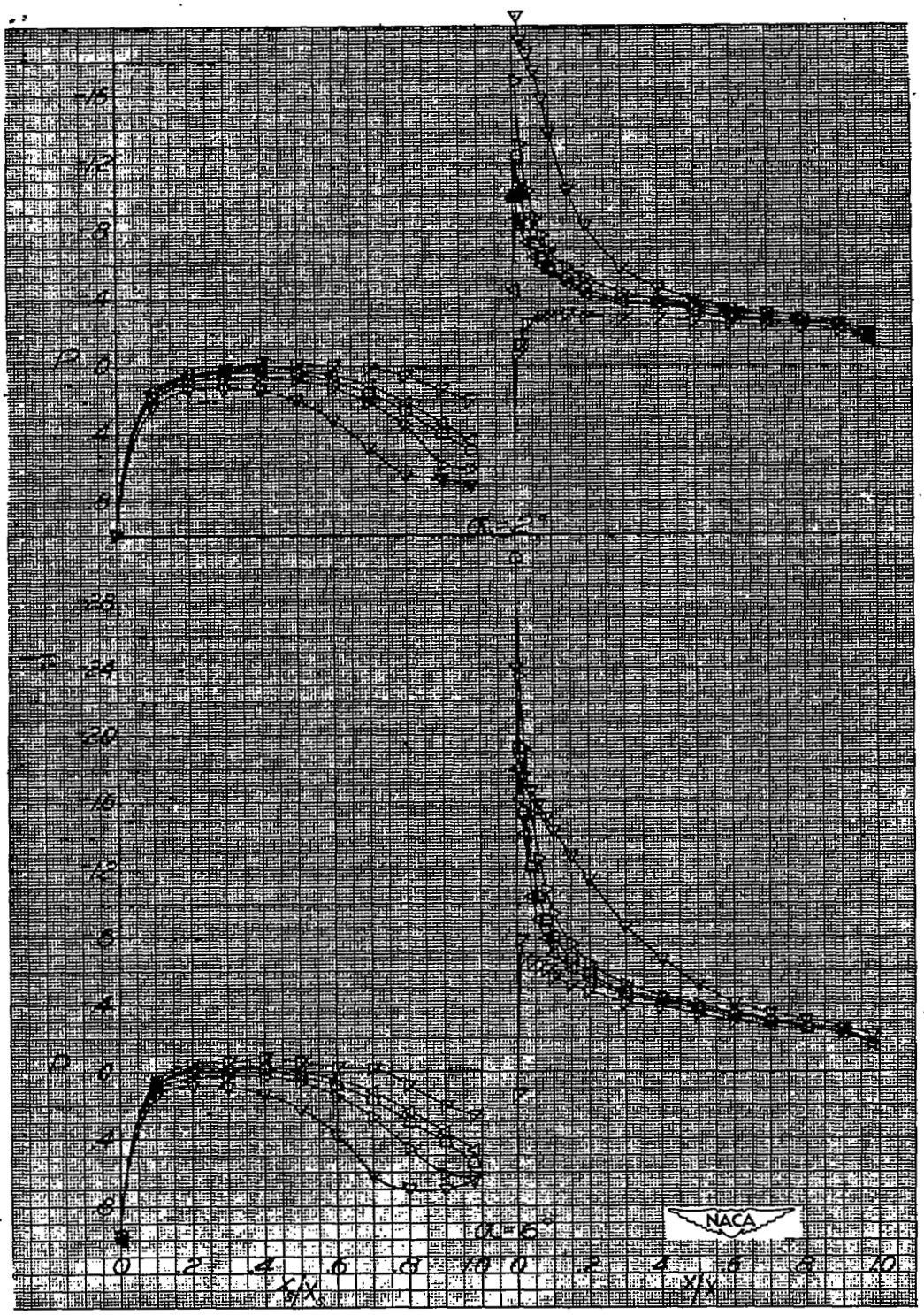


Figure 87.- Concluded.

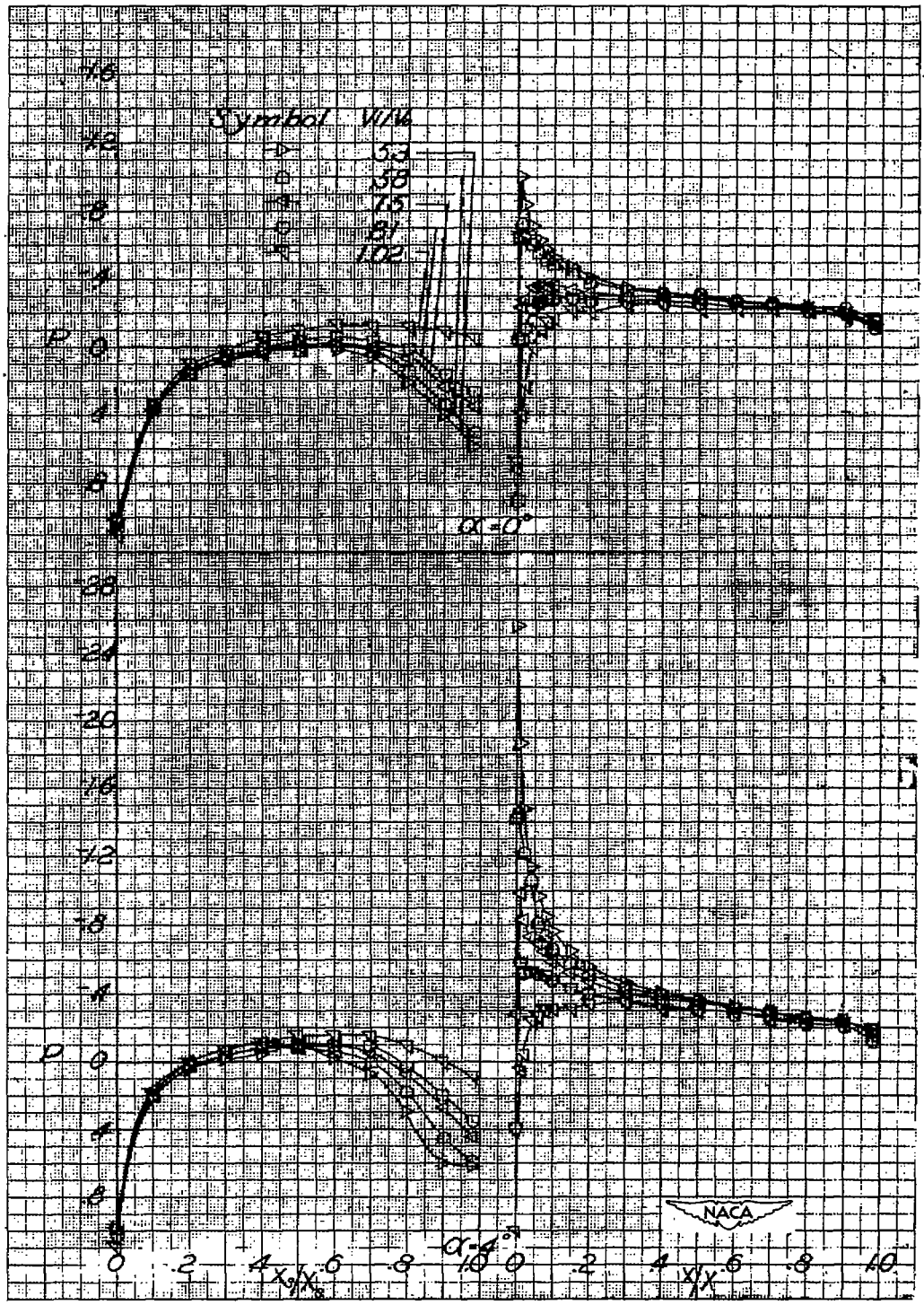


Figure 88.- Static-pressure distributions on top of NACA 1-85-050 cowling with NACA 1-60-080 spinner.

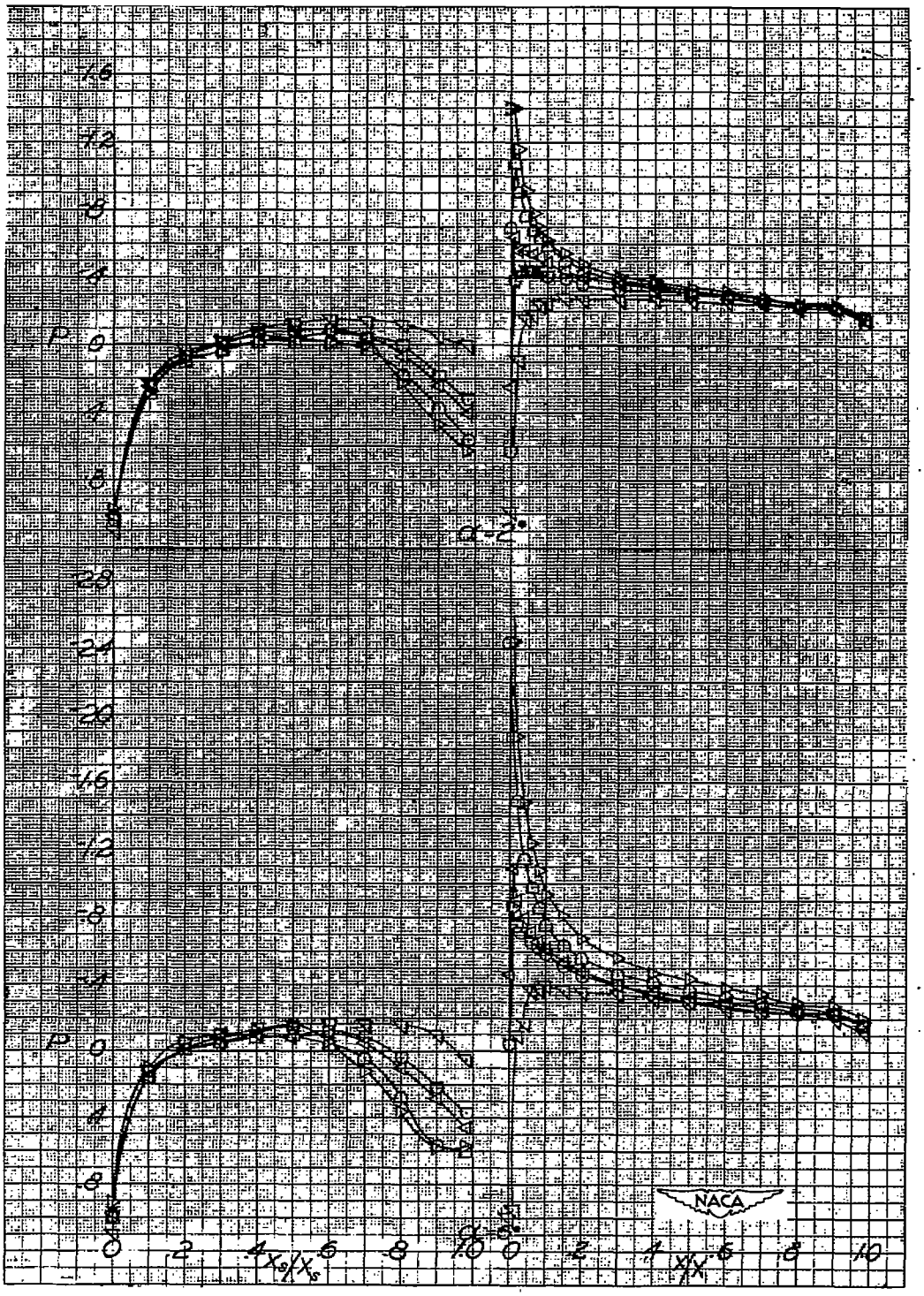
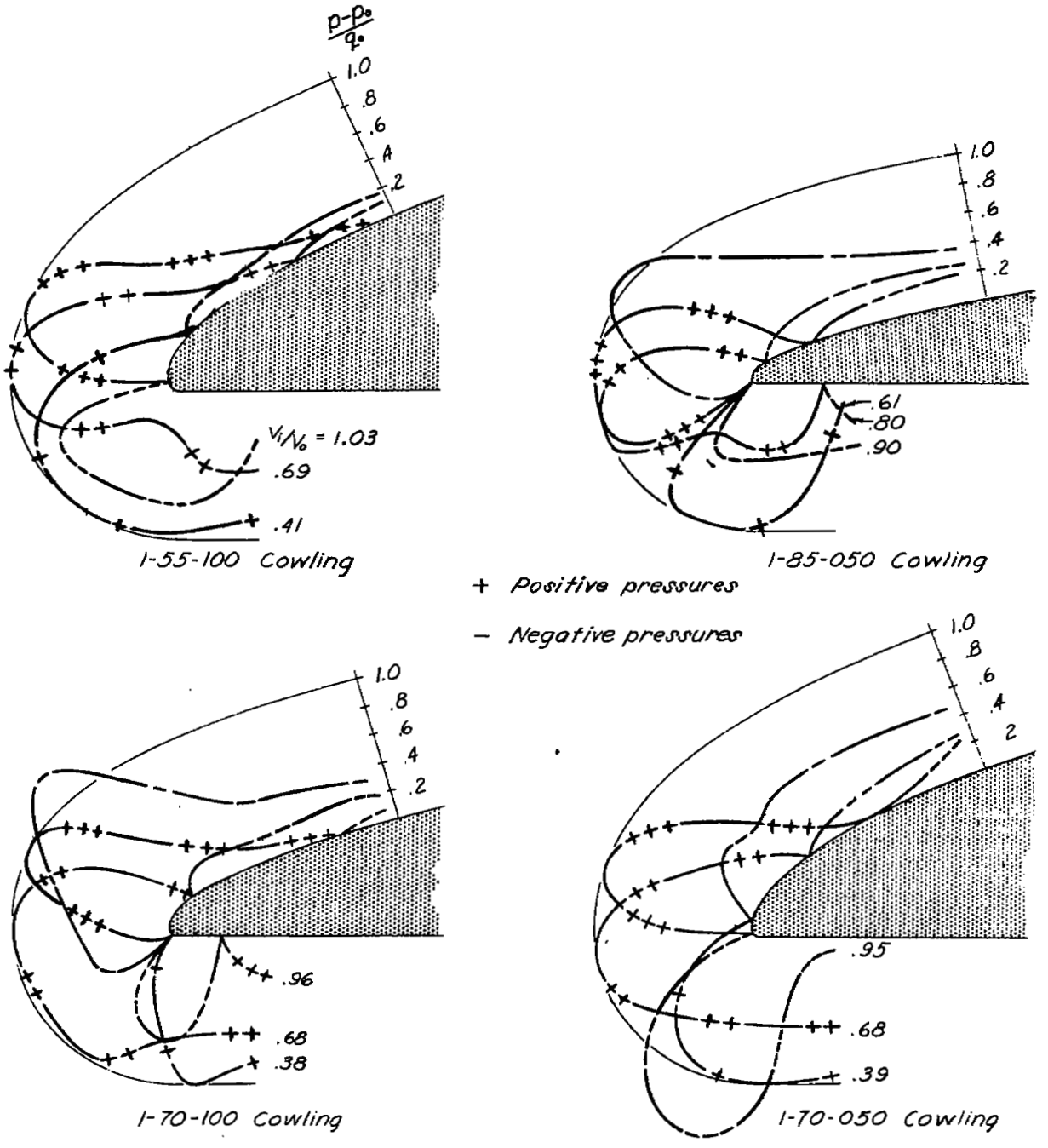
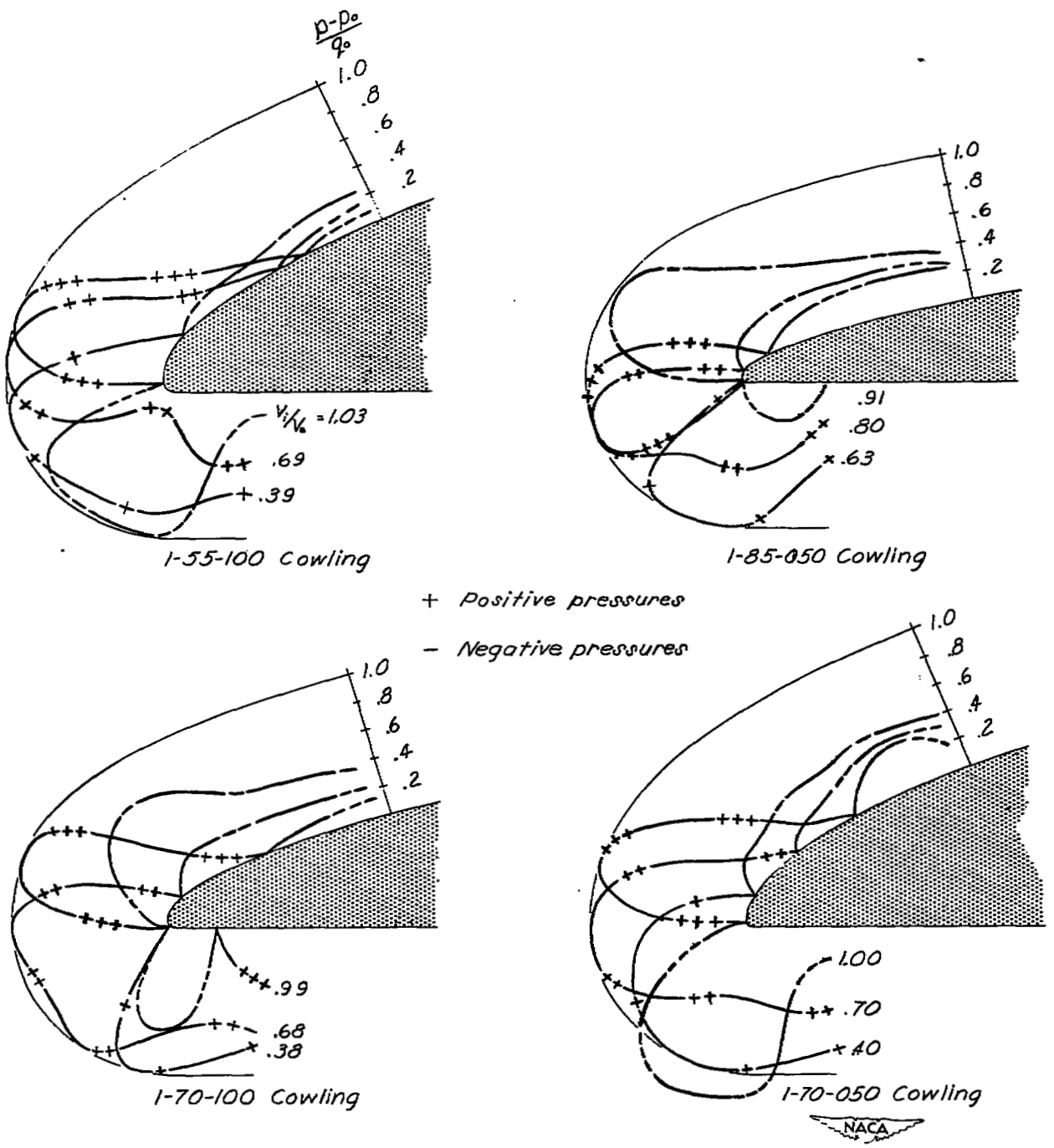


Figure 88.- Concluded.



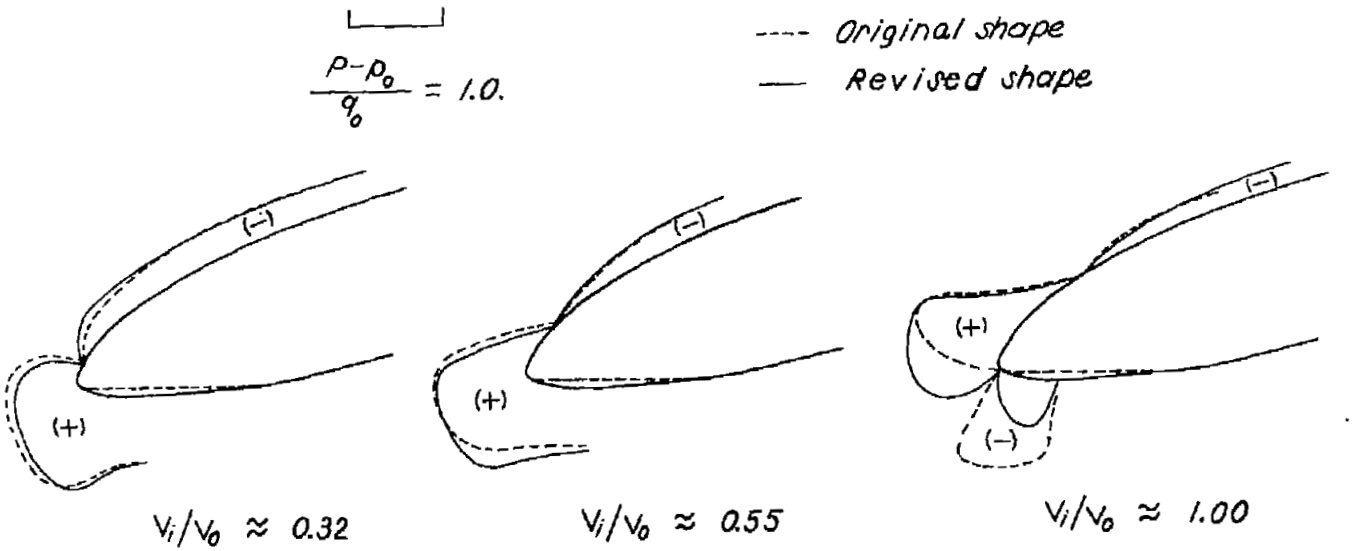
(a) No spinner.

Figure 89.- Static-pressure distributions around nose sections of representative NACA 1-series cowlings. $\alpha = 0°$. (Figure taken from reference 3.)

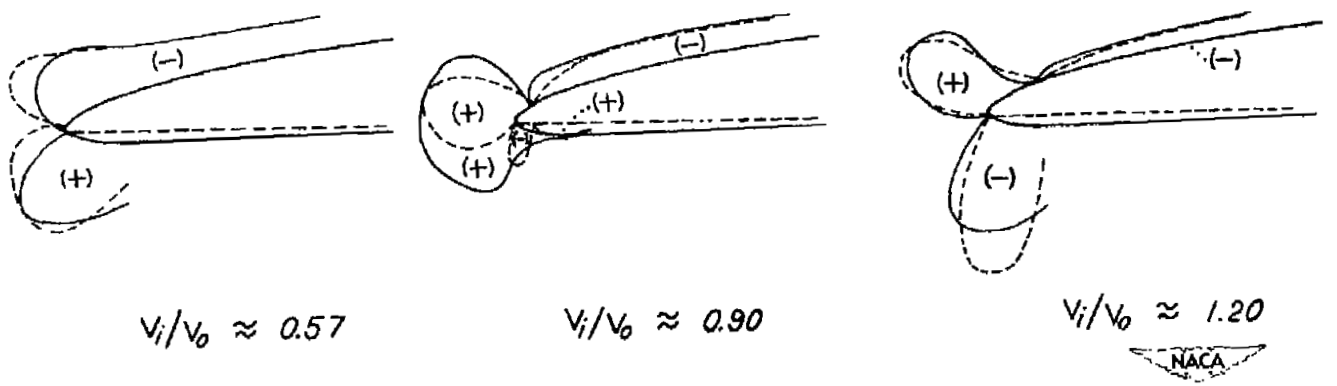


(b) With 1-40-060 spinner installed.

Figure 89.- Concluded.



(a) NACA 1-60-075 cowling with 1-40-060 spinner.



(b) NACA 1-85-050 cowling with 1-60-080 spinner.

Figure 90.- Effect of inner lip shape on static-pressure distribution around cowling nose. $\alpha = 0^\circ$. (Figure taken from reference 3.)

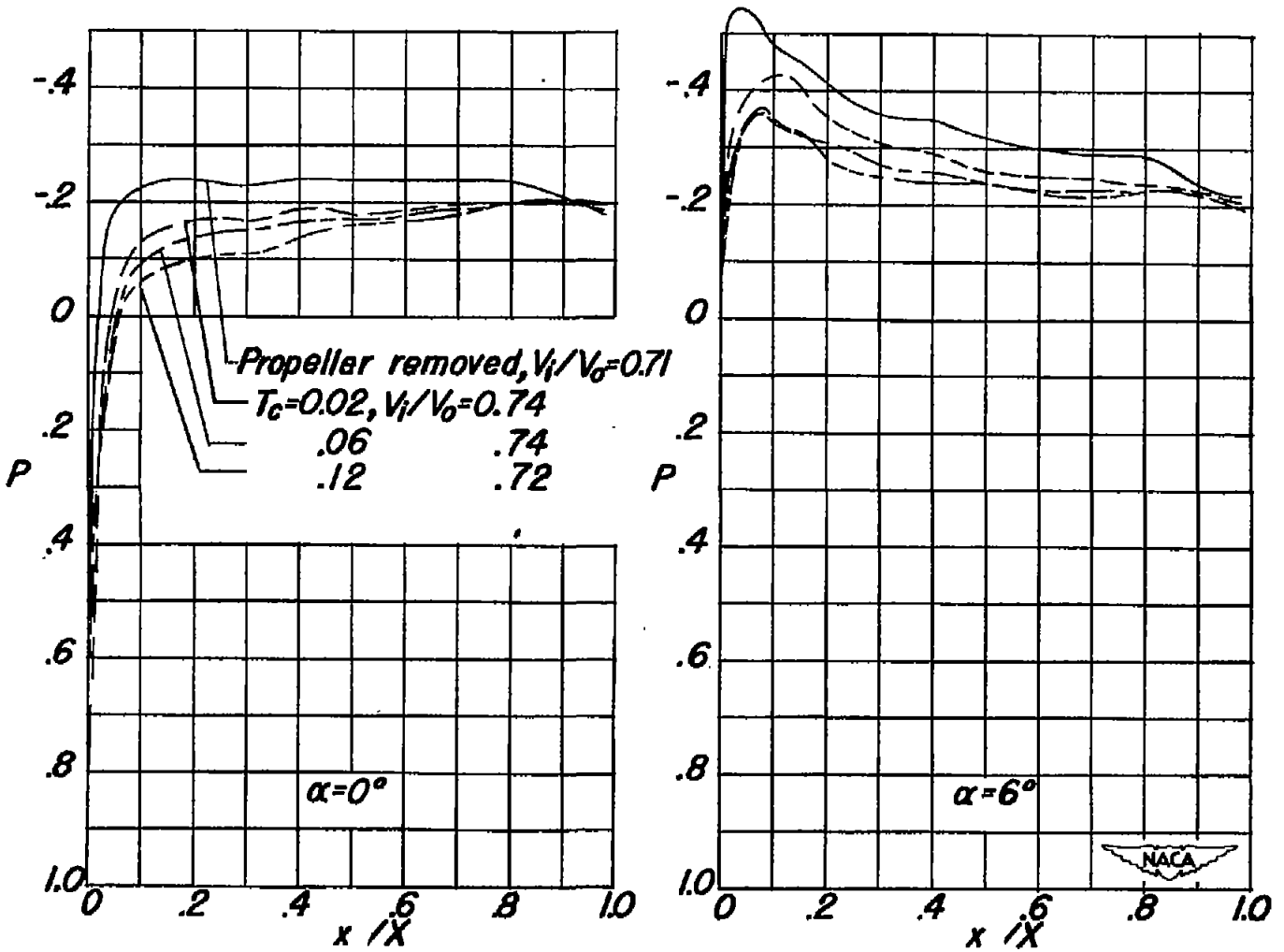


Figure 91.- Effect of propeller operation on static-pressure distribution on top of cowling. NACA 1-70-070 cowling with NACA 1-40-060 spinner; M = 0.13. (Figure taken from reference 3.)

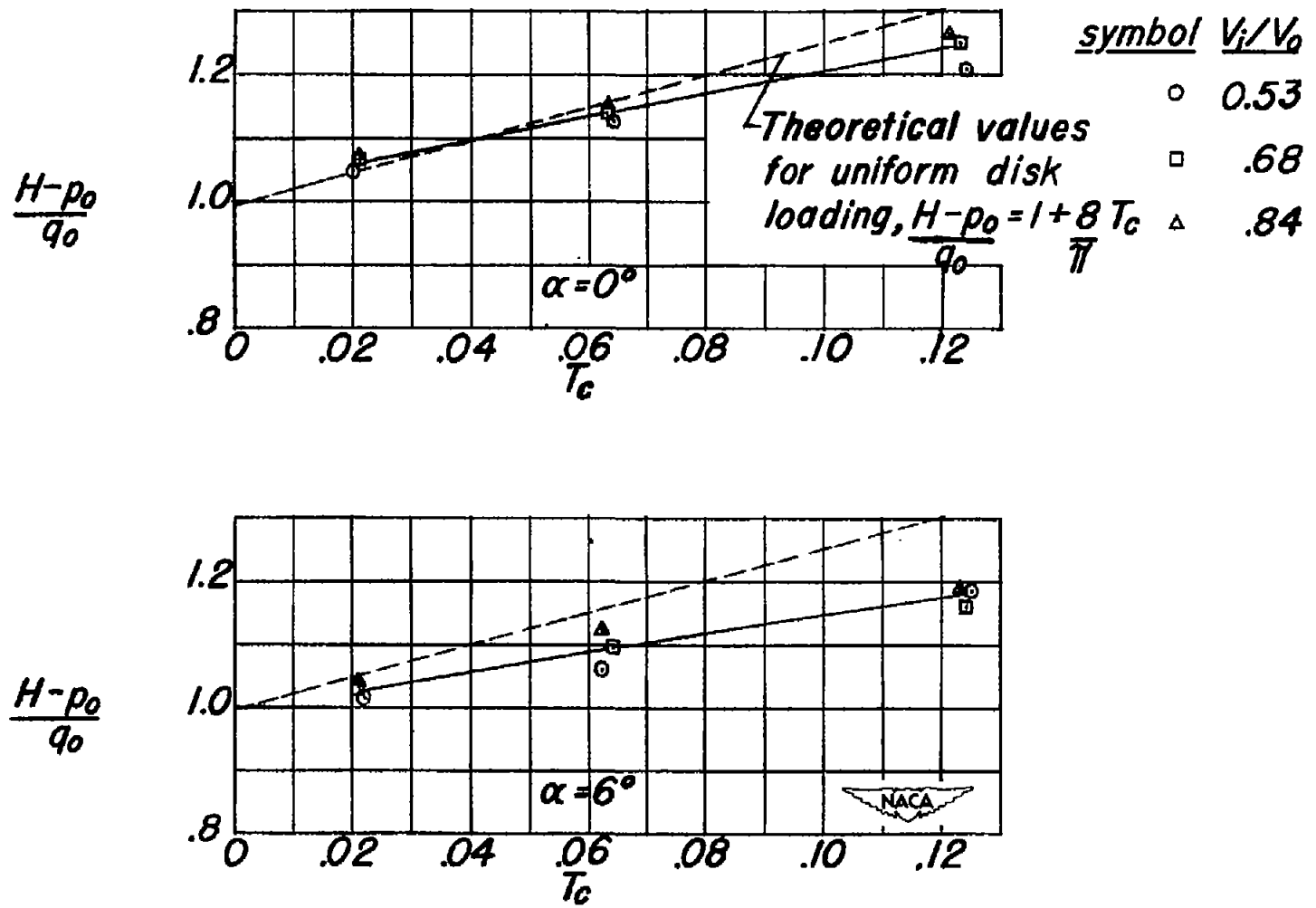


Figure 92.- Effect of propeller operation on average total-pressure coefficient for flow just outside boundary layer of cowling. NACA 1-70-075 cowling with NACA 1-40-060 spinner; M = 0.13. (Figure taken from reference 3.)